The Pasture Problem in Iowa

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THE PASTURE PROBLEM IN IOWA

AGRICULTURAL EXPERIMENT STATION
IOWA STATE COLLEGE OF AGRICULTURE
AND MECHANIC ARTS

C. F. Curtiss, Director

FARM CROPS AND
SOILS SECTION

AMES, IOWA
THE PASTURE PROBLEM IN IOWA

By W. H. Stevenson, L. W. Forman, P. E. Brown

In the Iowa Yearbook of Agriculture for 1922, it is estimated that the total area in the state utilized for pasture and grazing amounts to 10,130,000 acres, by far the largest portion of which is in what is known as permanent pasture. Calculating the annual production value of this acreage at $5.38 per acre, the total value for the state amounts to $56,525,000. It is apparent, therefore, that the pasture lands in Iowa provide a considerable, even the indirect, part of farm incomes, and that a poor growth of grasses and legumes means reduction in farm profits just as surely as poor yields of other crops on cultivated areas.

On some farms, only that land which is too poor, too rough, or too wet to cultivate is used for pasture, while all the rich, level, well drained areas are brought under cultivation. In some cases this poor, rough, or wet land provides sufficient pasturage. Usually it does not. In either case, it is only rarely that farmers make adequate effort to secure and maintain the best possible pastures. There is no question but that proper methods will bring about a better growth of the most desirable, most nutritious plants and provide more feed. Doubtless with such management it would be possible on many farms to secure all the pasture required on areas not suitable for cultivated crops. But even if this is not true, better pasturage on such areas would certainly mean that a smaller acreage of good cultivable land would be needed for pasture, and that there would be a more economic utilization of thousands of acres of good land in this state.

When cultivated crops are grown, many precautions are taken by the careful farmer to insure good yields. Tile is laid, manure is applied, limo and fertilizers are often used, good seed is secured and care is used in seeding. It is not expected that good crop yields will be produced continually without keeping the soil in good physical condition and well supplied with plant food. But after an area is seeded down to pasture most farmers seem to believe that it will continue to grow good pasture grasses many years without any particular soil treatment. The land may be well prepared and fertilized when it is seeded originally, but this will not suffice to keep it producing satisfactorily for the length of time for which pastures should be maintained to be most profitable. But often after a pasture is secured the grasses are allowed to grow year after year with no encouragement; no seedings are made to secure the most desirable plant growth and no fertilizers are applied to stimulate the plants. Naturally in such cases, the yields from the pasture are poor, weeds come in and flourish and smaller and smaller amounts of feed are provided. Then it becomes necessary to keep a poor and unprofitable pasture or to plow it up and seed down another area, both involving much difficulty and expense which might have been avoided by a proper care of the old pasture.

How to keep pastures productive and how to make old pastures more satisfactory are pasture questions which are probably of the most interest at the present time. If proper cultural and seeding treatments can be practiced and if the right kind of fertilizers can be applied, then the difficulty and expense involved in the frequent breaking up of pasture land and the seeding down of new areas can be avoided.

This circular explains treatments which may often serve to build up old bluegrass pastures and to keep such land producing the largest possible amount of feed for stock. Attention will be directed especially to the
results which may be secured by discing, reseeding and fertilizing, as indicated by the pasture experiment conducted by the Soils Section of the Iowa Agricultural Experiment Station on the Agronomy Farm at Ames during the past three years.

This experiment was laid out on an old bluegrass pasture on a typical area in the Wisconsin drift soil area. The treatments practiced include:

1. discing, which many farmers have already found to be of value;
2. reseeding with legumes, which has been practiced successfully on many farms;
3. applications of farm yard manure
4. applications of various commercial fertilizers used alone and in combinations, also with and without manure and with and without reseeding of legumes such as red and alsike clover.

Crop problems connected with pastures will also be mentioned briefly and some recommendations regarding pasture crops are included which have been prepared by the Farm Crops Section. Inquiries along crop lines may be sent at any time to the Farm Crops Section and more complete information may be secured by correspondence. The Soils Section may be consulted in regard to soil problems and advice may be secured for special cases which cannot be discussed in this publication.

SECURING A GOOD PASTURE

A good stand of the right kind of grasses and legumes capable of making good yields is essential if the pasture is to prove permanent. Obviously it is neither desirable nor economic to seed down an area to pasture frequently. The longer a field can be kept in good pasture, the more profitable it is. If a good initial growth of pasture grasses is secured the problem of maintenance is much simplified. This alone is insufficient, of course, for a pasture can no more be left uncared for and remain satisfactory than can any other land in cultivated crops. Securing a good pasture is, however, the first requisite for permanency.

Several things must be done in order to get a good pasture. These may be summarized briefly by saying that all of the practices which are commonly used by good farmers to obtain the best yields of ordinary farm crops are just as necessary when a first class pasture is desired. The seed bed must be properly prepared, the land must be manured and fertilized, good seed must be secured and the proper seeding mixture must be employed. All these factors are equally important and if any one is overlooked, the pasture may fail to give good yields. It should be emphasized that the proper fertilization of the land is quite as important in many cases as the securing of good seed. Too frequently this fact is overlooked. No matter how good the seed may be, if the land is unproductive and does not contain the necessary amounts of plant food constituents, the plants will not thrive and weeds will gradually come in and may in time drive out most of the grass.

PREPARATION OF THE SEED BED

The first step necessary to secure good soil conditions for pasture is to provide adequate drainage. If the land is too wet the grasses and legumes will not flourish. Tiling out such land may insure the success of the pasture and the expense involved will be well worth while. Adequate tile of sufficient size should be provided and properly laid to carry away excess moisture. Sometimes the deepening or straightening of small streams, with or without the installation of tile, may provide suitable conditions for excellent pastures on land which has been of little value.
Proper plowing and cultivation of the land before seeding will provide a good, fine, mellow seed bed which is so essential for pasture plants. The subsurface soil should be firm but not hard. It is for this reason that drainage of the land is so often necessary. The use of lime and manure will also help to provide the best physical conditions in the soil, both at the surface and in the lower soil layers. Deep plowing is not generally desirable just preceding the seeding down of an area to pasture. As a rule the best pastures will be secured on land which has been plowed properly for previous crops. The best root development of the plants will be secured only on soils which have been well tilled deeply enough to provide a fine, firm seed bed. Thorough discing after plowing is of considerable value in putting soil in the best physical condition and it also aids bacterial action and the production of adequate amounts of available plant food.

FERTILIZATION

The application of manure is one of the best means of fertilizing land which is to be seeded down. The beneficial effects which are so commonly noted when manure is used for other farm crops are quite as great in the case of pastures, even tho not so apparent. Manure improves the physical conditions of the soil, opening up heavy, tight soils and providing better air conditions, and making loose, open, sandy soils more retentive of moisture and less subject to losses of plant food. Chemically it provides much plant food, nitrogen, phosphorus and potassium, and it also supplies large amounts of organic matter. It also introduces numberless bacteria which bring about the production of available plant food. Thus it has a three-fold value on soils. Eight tons of manure per acre is the usual amount employed. Larger amounts may sometimes be used to advantage, especially on very light, sandy soils, but they are not recommended. The need for manure on all farm land is so great that large amounts should not be employed on any one area, leaving other fields untreated.

Many Iowa soils are acid and if good legume growth is to be secured lime must be applied. The soil should be tested for acidity and the necessary amount of limestone added before seeding. Samples of soil may be sent to the Soils Section of the Iowa Agricultural Experiment Station, where they will be tested free of charge. The lime should be distributed over the land after plowing and thoroly disced in before seeding. A lime spreader will prove most satisfactory for applying the limestone but a manure spreader may also be used.

Commercial fertilizers applied to land to be seeded would probably prove profitable in many cases. Unfortunately definite information along this line is lacking. Experiments have shown, however, that phosphates often prove of value on Iowa soils in increasing the growth of clovers, alfalfa and other legumes, and the yields of general farm crops. It seems quite probable, therefore, that on many soils, and particularly on land which is not highly productive, an application of acid phosphate at the rate of 150 pounds per acre, applied just prior to seeding, might prove of distinct value. Advice regarding the use of this fertilizer in individual cases may be secured by writing to the Soils Section. If acid phosphate has given profitable returns on a certain soil type in field tests, then the use of this material would probably give good results on the same soil when seeded to grass. Complete commercial fertilizers are not recommended for use now, as thus far experiments have shown that acid phosphate usually gives quite as large effects and often more economic returns.
GOOD SEED

Good seed should always be employed. It should be free from weeds and have strong vitality. Cheap seed is apt to be poor in germinating power and may contain injurious weed seeds. Tests for germinating power may be made as described in Circular No. 39 of the Iowa Agricultural Experiment Station. Samples may be sent to the station, however, and tested free of charge, for purity, germination and genuineness.

SEEDING MIXTURES

Various seeding mixtures may be employed for different conditions, but the following are suggested by the Farm Crops Section of the Iowa Agricultural Experiment Station.

(1) Timothy, 9 pounds; medium red clover, 4 pounds; alsike, 2 pounds.
(2) Timothy, 6 pounds; orchard grass, 4 pounds; medium red clover, 4 pounds; alsike, 2 pounds.
(3) Brome grass, 10 pounds; orchard grass, 4 pounds; medium red clover, 2 pounds.
(4) Brome grass, 6 pounds; orchard grass, 3 pounds; timothy, 3 pounds; sweet clover, 6 pounds; medium red clover, 2 pounds; alsike, 2 pounds.

These mixtures may be varied greatly, both as to kinds of seed and amounts, to suit individual conditions. In determining upon crops to be included, consideration must be given to soil conditions, cost and availability of seed, kind of livestock to be pastured and the quality of the feed produced. A mixture of several different legumes and grasses will usually give the largest amount of palatable and nutritious grazing from early spring until late fall. In establishing permanent pasture, quick growing crops are necessary to supply forage for the first few years while the slower growing, sod producing plants are getting well established.

Blue grass is probably the best permanent pasture grass for Iowa and while it ultimately makes its appearance in most pastures without seeding, its growth can be hastened by adding six to 10 pounds of seed per acre to other mixtures.

Timothy is not particularly desirable for pasture seedings, but it is usually included because it gives a stand easily and the seed is comparatively cheap and usually of strong vitality.

Orchard grass and smooth brome grass are both excellent pasture grasses. While orchard grass grows best on fertile, well drained soil, it thrives better than either timothy or blue grass under dry, hot growing conditions. It does not form a good sod, yet it is especially desirable in pasture mixtures because it begins growth early in the spring, grows better than bluegrass during the hot summer months, recovers quickly from heavy grazing, and continues to grow until late in the fall.

Brome grass is vigorous in growth and leafy, producing a dense, heavy sod. It is extremely drought resistant, grows well on most Iowa soils and is especially recommended for seeding on land subject to drought. Cattle are exceptionally fond of this grass and tend to kill it out by pasturing too closely.

Alsike can be included to advantage in seedings made on average soils and on soil not well drained. Sweet clover is drought resistant but is not recommended for seeding on acid soils which have not been corrected by the use of lime. Mammoth clover will make a stand when soil conditions are unfavorable for medium red clover.
SEEDING

Pasture seedings are usually made with a small grain crop which serves as a nurse crop. Suggestions along this line and a discussion of methods of seeding, both with and without a nurse crop, and of the time, rate and depth of seeding are given in Circular 39 of the Iowa Agricultural Experiment Station.

MAINTAINING A GOOD PASTURE

After a good pasture has been secured, the problem of maintenance becomes important. Aside from the difficulties due to improper grazing, which are too well known to need more than mere mention, many pastures produce too little feed because of poor soil conditions. The grasses and clovers do not flourish because of lack of adequate supplies of available plant food. Then weeds come in and gradually replace the desirable plants. The lack of plant food in the soil may be due to an actual deficiency of the plant food elements, or to an insufficient production of available food, which is usually brought about by poor air conditions in the soil and by weak bacterial action.

The supplying of proper food for the pasture grasses, then, is fundamental in maintaining a good pasture. This may be accomplished by disking, which opens up the soil, admits air and permits of more intense bacterial action and hence leads to a better production of available plant food, or by the addition of fertilizers which supply those constituents which may be lacking in the soil. Furthermore, to keep the best stand of the most desirable pasture grasses and legumes, it is necessary to reseed. By a combination of disking, seeding, and fertilizing, it is generally possible to maintain a good pasture and also to bring an old pasture back to a condition of satisfactory productivity.

THE PASTURE EXPERIMENT AT Ames

In the pasture experiment at the Agronomy Farm at Ames, disking is the basic treatment which is being employed for the improvement of an

![Plan of the pasture experiment at Ames, showing the treatments tested.](image)

**Legend:**
- C = Check
- CCF = Commercial Composite Fertilizer
- MP = Mineral Phosphate
- AP = Acid Phosphate
- D = Dressed
- SN = Sodium nitrate
- BS = Basic Slag
- R = Re-seeded
- AS = Ammonium sulfate
- M = Monocrotonic
- RP = Rock Phosphate
- G = Gypsum
The beneficial effects of discing, reseeding and manuring an old bluegrass pasture are shown in the pasture experiment at Ames. The effects of reseeding, manuring and fertilization are also being determined by the use of a good mixing mixture, a normal application of manure and the application of certain commercial fertilizers. Various combinations of these treatments are also being used. The plan of the experiment is shown in Fig. 1.

The plots on which these tests are being carried out are 10 feet in width by 150 feet in length. They are separated by one foot strips which prevent any overlapping of fertilizer treatments. A strip 10 feet wide is left as a border at the south end of the series of plots. On the south end of each plot on an area which is 10 feet by 22 feet in size, the green weights of grass were secured in 1921 and 1922, by clipping with a lawn mower. In 1923, the crop was harvested as hay and air dry weights of both the first and second cuttings were secured. Only the data secured in 1923 will be discussed in this circular.

It should be noted that the results given from this experiment were obtained on areas which were mown and not from pastured areas. During the coming season, the north half of the plots will be put under control pasturing and an attempt made to determine the preference of the stock for the pasturing under the different treatments and the effect of such pasturing on yields and on the type of vegetation.

In each of the three years since the experiment was begun all of the plots except numbers 1 and 47 have been double disced with a four horse disc, cutting to a depth of about two inches. The discing was done as early in the spring as the soil became sufficiently dry. This was generally early in March. Discing pastures late in the spring is not desirable and may even be injurious.

In 1921 and 1922, the reseeded plots received a mixture of six pounds of medium red clover and two pounds of alsike, broadcasted, immediately after discing. The reseeded plots were then harrowed at right angles to the direction of discing with the teeth of the harrow laid flat. In 1923, the reseeding mixture consisted of two and one-half pounds of medium red clover, three-fourths pound of alsike clover, two and one-half pounds of biennial white sweet clover and three and three-fourths pounds of alfalfa.

Manure was applied at the rate of eight tons per acre each year. The amounts of the commercial fertilizers used were as follows:

- Sodium nitrate ........................................ 200 pounds per acre annually
- Ammonium sulfate .................................. 150 pounds per acre annually
- Acid phosphate ...................................... 200 pounds per acre annually
- Muriate of potash .................................... 25 pounds per acre annually
- Complete commercial fertilizer (2-12-2) .......... 267 pounds per acre annually
- Rock phosphate ...................................... 2,000 pounds per acre once in 4 years
- Basic slag ......................................... 2,000 pounds per acre once in 4 years
- Gypsum ............................................. 1,000 pounds per acre once in 4 years

Limestone was applied in the spring of 1921 to the east half of each plot, at the rate of two tons per acre. The lime requirement of the soil was determined by the Truong method and found to be one ton per acre. The soil in this particular bluegrass pasture was evidently only very slightly acid and at no time during the experiment was any effect noted from the addition of the lime. The yields on the treated plots were therefore taken without regard to the lime application. It should be noted, *A complete commercial fertilizer is one which contains the three elements of plant food, nitrogen, phosphorus and potassium.
however, that additions of lime to other soils having a more pronounced acidity would probably prove decidedly beneficial. In fact it has been the experience of many farmers that lime is a very valuable addition to pastures, permitting as it does, the maintenance of the best growth of the clovers, which will often die out under conditions of high soil acidity. Tests of the soil will show whether or not it needs lime to correct acidity and trial applications, at least, should be made whenever the soil shows a high degree of acidity or lime requirement. Finely divided limestone of a good quality should be employed when pastures are to be treated. Applications should be made before discing by means of a lime spreader or by the use of a manure spreader.

DISCING

The effects of discing alone on an old bluegrass pasture are shown in the results secured in this pasture experiment in the year 1923. The yields on plots one and two, shown in table I, indicate that this treatment may bring about a worth while increase in the growth of the pasture grasses.

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Treatment</th>
<th>Tons per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Check</td>
<td>1.19</td>
</tr>
<tr>
<td>2</td>
<td>Disced</td>
<td>1.39</td>
</tr>
<tr>
<td>47</td>
<td>Disced</td>
<td>0.74</td>
</tr>
<tr>
<td>38</td>
<td>Disced</td>
<td>0.87</td>
</tr>
</tbody>
</table>

The results secured on plots 47 and 38, given in table I, also show an increase for the discing, altho the yield of hay on these plots was less than that secured at the other end of the series of plots, owing to the natural soil and pasture differences.

Apparently discing may give a distinct increase in plant growth on old bluegrass pastures and as a basic treatment for such pastures it may be very desirable. It should be recalled that the same treatment had been practiced for the two years preceding the securing of these results. The average green weights of grass cut on the plots in 1921 and 1922 show an increase in both cases for the discing. Thus it seems that desirable effects may be secured each year from discing, altho the effects might be less evident over a period of years. It is of interest to note that in this test increases occurred under different seasonal conditions. In 1923 the rainfall was very evenly distributed throughout the season, while in the two preceding years there were periods of drought and of excessive rainfall. Perhaps later results may confirm the indications obtained in this experiment that discing may prove beneficial, regardless of the seasonal conditions, provided they are not extremely abnormal, but conclusions along this line are not yet possible.

It should be emphasized that pastures should not be disced too late in the spring, the discing should not be too deep, and the best results will not be secured if reseeding and fertilization are not practiced in connection with the discing. With these precautions and supplementary treatments, discing may generally be expected to bring about very profitable effects.

RESEEDING

As a supplement to discing, the reseeding of old pastures seems very desirable. Many farmers have secured large beneficial effects from reseeding and frequently pastures which have been giving very poor yields have been made highly satisfactory by following this practice after a thorough discing. The introduction of legumes into the pasture provides better feed and keeps the pasture thickly seeded. Thus no bare spots are allowed to develop and the growth of undesirable weeds is prevented. When proper fertilization is practiced along with reseeding the largest beneficial effects
on old bluegrass pastures may be secured. But reseeding alone, following disking, may prove very effective as is indicated by the results obtained in the pasture experiment on the Agronomy Farm. The following figures in table II give the dry weights of the hay crop secured in 1923:

The increase in plant growth on the reseeded plot is shown quite distinctly in table II and the results serve to confirm the conclusion that reseeding may often be a very important practice for the improvement of pastures. It may be mentioned that the green weights of grass taken in 1921 and 1922 likewise show an increase, on the average, for the reseeded plots over those merely disced. Beneficial effects seem to be brought about under quite different seasonal conditions.

Other mixtures for reseeding than those used in this work, may often be used to advantage and the following are suggested by the Farm Crops Section:

1) Medium red clover, 2 to 3 pounds; alsike, 2 to 3 pounds; biennial white sweet clover, 2 to 3 pounds.

2) Medium red clover, 2 pounds; alsike, 2 pounds; biennial white sweet clover, 2 pounds; alfalfa, 2 pounds; white Dutch, 1 pound.

The amount of seed used will depend upon the condition of the pasture. If the pasture is in poor condition three pounds per acre of each of the three clovers suggested in (1) will often be found desirable, while two pounds of each per acre will be sufficient on pastures with heavier stands of grass and after the first reseeding has been made.

FERTILIZATION

Various commercial fertilizers may be applied to old pastures in the attempt to rejuvenate them but little is known of the value of different materials. The pasture experiment on the Agronomy Farm at Ames was planned primarily to test the use of a number of common commercial fertilizers on an old bluegrass pasture and 38 of the 47 plots in the experiment were treated with single materials, or with combinations of various commercial fertilizers, with and without manure and reseeding. Comparisons were also made of the effect of the fertilizers with that of manure.

The influence of the different materials when used on disced plots without reseeding is shown in table III which gives the figures obtained in 1923. The yields given are the dry weights of the two crops of hay:

These figures indicate very little effect from any of the applications except the manure. The increase secured from the use of manure was considerable and it is apparent that this material may be of large value in improving the growth of pasture grasses. Farm experience amply confirms this conclusion. The complete commercial fertilizer, the ammonium sulfate and the acid phosphate showed slight gains but the differences were too small to be significant. The other commercial fertilizers

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Treatment</th>
<th>Tons per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Disced</td>
<td>1.19</td>
</tr>
<tr>
<td>4</td>
<td>Disced + manure</td>
<td>1.96</td>
</tr>
<tr>
<td>5</td>
<td>Disced + complete commercial fertilizer</td>
<td>1.28</td>
</tr>
<tr>
<td>6</td>
<td>Disced + sodium nitrate</td>
<td>1.06</td>
</tr>
<tr>
<td>7</td>
<td>Disced + ammonium sulfate</td>
<td>1.23</td>
</tr>
<tr>
<td>8</td>
<td>Disced + rock phosphate</td>
<td>1.17</td>
</tr>
<tr>
<td>9</td>
<td>Disced + acid phosphate</td>
<td>1.23</td>
</tr>
<tr>
<td>10</td>
<td>Disced + basic slag</td>
<td>1.17</td>
</tr>
<tr>
<td>11</td>
<td>Disced + muriate of pot ash</td>
<td>1.09</td>
</tr>
<tr>
<td>12</td>
<td>Disced + gypsum</td>
<td>0.95</td>
</tr>
</tbody>
</table>

*The yield given is the average of plots 2 and 13 both disced only.
showed no gains and sometimes decreases are noted, due undoubtedly to variations in the soil in different parts of the pasture. The check yield given is the average of the disced plots at the two ends of the group of fertilized plots (plot 2, 1.39 ton, and plot 13, 1.00 ton). It seems evident from the results that these commercial fertilizers were of little use on disced pasture on this soil type but the application of manure was very effective in increasing the yield.

The effects of the same fertilizers on disced pasture, which was reseeded, was very different. The reseeding apparently is an operation of large importance. Increases are noted from all the treatments when reseeding was practiced, as are indicated in the figures in table IV.

Again the manure brought about a distinctly beneficial effect but much larger benefits were noted where the commercial fertilizers were employed. The acid phosphate showed the largest effect, but the rock phosphate, basic slag, complete commercial fertilizer, ammonium sulfate and muriate of potash each gave just about as great an influence.

The results are so close that no conclusions are permissible regarding the relative values of the various materials. It seems, however, that the phosphorus carriers had the largest effect and experiences with the application of phosphates to this soil type for other crops indicate that phosphorus is the element most likely to be lacking in the soil and fertilizers supplying it are most apt to give results.

It is of particular interest to note that the manure had less effect on these reseeded and disced plots than that shown by the various commercial fertilizers. Perhaps other fertilizers may serve to improve pastures and the manure may be utilized on the cultivated land of the farm to better advantage. This conclusion, however, must be confirmed by other data before such a practice can be recommended. Further results are also necessary before any one commercial fertilizer can be recommended for use on reseeded, disced, bluegrass pastures. It is suggested, however, that acid phosphate might be tested on a part of a pasture to learn what its effect may be. Many soils respond to phosphorus when applied in this form to other crops, and it seems quite probable that results, similar to those secured in the experiment described here, may be secured under many farm conditions.

The addition of the different commercial fertilizers with manure, but without reseeding, exerted beneficial effects on the pasture, as will be noted in the figures in table V, showing the yields from the third group of plots.

The effect of the commercial fertilizers was really not as large as these figures would seem to indicate, as the disced and manured plot is not immediately adjacent to this group of fertilized plots. The average yield of the two disced, unmanured, unfertilized plots at each
side of these plots was higher than that of the disced plot adjoining the manured plot, and assuming similar effects of manure in both parts of the pasture, the yield on plot four should probably be calculated at about three tons rather than at 1.96 tons.

The differences in the yields on the disced plots indicate natural soil variations and differences in the pasture at the start of the experiment. Taking the higher figure, however, for the disced manured plot, practically all of the commercial fertilizers showed definite increases.

Again it is difficult to draw conclusions regarding the value of the various materials as the results are so similar. The ammonium sulfate and the complete commercial fertilizer, however, seem to have been somewhat more effective than the other materials. The sodium nitrate had a smaller influence. The acid phosphate and the rock phosphate showed still smaller effects while the muriate of potash gave practically no increase.

While definite recommendations cannot be made from the above figures, they do indicate the possibility of a profitable use of certain commercial fertilizers in addition to manure on disced pastures. Further tests along this line are very desirable. While the results seem to show as large effects from the combination of fertilizer treatments with manure as with reseeding without manure, the practice of reseeding is a most desirable one and strongly to be recommended. It is not only a question of the largest possible yield which is all that these results show but also a question of the securing of pasturage of the highest nutritive value which frequently can only be secured thru reseeding, or a reintroduction of the most nutritious plants such as legumes. On other pastures, too, the effect of the reseeding might be much greater than in this experiment, depending upon the actual character of the plant growth occurring on them.

In the next group of plots, tests were made on the effects of combinations of the different commercial fertilizers on disced pasture. The results secured were as shown in table VI.

These tests showed some increases where two commercial fertilizers were employed but in several cases, no gains were secured, just as was noted with the single fertilizer additions to disced pasture. The apparent decrease in plots 36 and 37 is attributed to variations in the soil and pasture conditions.

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Treatment</th>
<th>Tons per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>Disced</td>
<td>1.74</td>
</tr>
<tr>
<td>31</td>
<td>Disced+acid phosphate+sodium nitrate</td>
<td>2.42</td>
</tr>
<tr>
<td>32</td>
<td>Disced+acid phosphate+ammonium sulfate</td>
<td>2.17</td>
</tr>
<tr>
<td>33</td>
<td>Disced+acid phosphate+muriate of potash</td>
<td>1.64</td>
</tr>
<tr>
<td>34</td>
<td>Disced+rock phosphate+sodium nitrate</td>
<td>1.96</td>
</tr>
<tr>
<td>35</td>
<td>Disced+rock phosphate+ammonium sulfate</td>
<td>2.18</td>
</tr>
<tr>
<td>36</td>
<td>Disced+rock phosphate+muriate of potash</td>
<td>1.17</td>
</tr>
<tr>
<td>37</td>
<td>Disced+sodium nitrate+muriate of potash</td>
<td>1.31</td>
</tr>
</tbody>
</table>

*The yield given is the average of plots 30 and 38 disced only.
TABLE VII. EFFECT OF COMMERCIAL FERTILIZERS WITH MANURE ON RESEEDED DISCED PLOTS.

<table>
<thead>
<tr>
<th>Plot No.</th>
<th>Treatment</th>
<th>Tons per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>38</td>
<td>Disced</td>
<td>0.87</td>
</tr>
<tr>
<td>14</td>
<td>Disced + manure + reseeded</td>
<td>2.80</td>
</tr>
<tr>
<td>39</td>
<td>Disced + manure + reseeded + complete commercial fertilizer</td>
<td>2.41</td>
</tr>
<tr>
<td>40</td>
<td>Disced + manure + reseeded + sodium nitrate</td>
<td>2.95</td>
</tr>
<tr>
<td>41</td>
<td>Disced + manure + reseeded + ammonium sulfate</td>
<td>3.61</td>
</tr>
<tr>
<td>42</td>
<td>Disced + manure + reseeded + acid phosphate</td>
<td>2.29</td>
</tr>
<tr>
<td>43</td>
<td>Disced + manure + reseeded + rock phosphate</td>
<td>2.51</td>
</tr>
<tr>
<td>44</td>
<td>Disced + manure + reseeded + muriate of potash</td>
<td>3.08</td>
</tr>
<tr>
<td>45</td>
<td>Disced + manure + reseeded + acid phosphate + muriate of potash</td>
<td>3.46</td>
</tr>
<tr>
<td>46</td>
<td>Disced + manure + reseeded + acid phosphate + muriate of potash + sodium nitrate</td>
<td>4.23</td>
</tr>
</tbody>
</table>

Conditions. The acid phosphate with sodium nitrate or with ammonium sulfate gave increases but with the muriate of potash no effect was evidenced. Similarly the rock phosphate with the nitrogenous materials showed some gains but less than those given by the same nitrogen carriers with acid phosphate. Again the combination with muriate of potash had no effect. The sodium nitrate and muriate of potash had no beneficial influence and this would indicate that phosphorus is the element most needed in this soil. The results serve to confirm the earlier conclusion that acid phosphate might often be used advantageously on dissected pastures and tests are very desirable.

The influence of various commercial fertilizers in combination with manure on dissected plots reseeded is shown in Table VII.

Little or no effect was evidenced from some of the single commercial fertilizers added to the manured, dissected and reseeded plots. The ammonium sulfate, the muriate of potash and the combination of acid phosphate with the muriate and with the muriate and the nitrate, however, showed increases. The dissected, reseeded and manured plot was not in the same part of the pasture as the fertilized plots and hence the yield may be somewhat greater than would have been secured on a plot in this group merely manured, dissected and reseeded owing to the difference in the soil and pasture conditions. However, this fact serves only to show that the increases from the fertilizer additions, wherever secured, may be considered quite definite. The dissected plot adjacent to this group of plots gave a much lower yield than the dissected plots adjoining the group which were reseeded and fertilized without manure. Hence the natural yield in the pasture in this part of the field may be considered to be lower and the fertilizer effects were really probably greater than the figures show.

Comparing the effects of the manuring and reseeding with the disking alone, where the yield was 0.87 tons per acre, the beneficial effect was very pronounced. The previous results showing the benefits of manuring and of reseeding are amply confirmed by these figures. Apparently the use of manure on dissected pastures is a most desirable practice. Reseeding with a good mixture is likewise desirable and the effects of reseeding are much greater where the pasture is manured or fertilized at the same time. If the growth of the plants introduced into the pasture by reseeding is to be most successful, they must be provided with available food either thru the manure which supplies plant food and also increases the production of available material in the soil, or thru the addition of the food itself in a fertilizer containing it in an available form.

The effect of additions of commercial fertilizers along with manure is not nearly so definite on reseeded land as where reseeding is not practiced, but there are indications that some materials or mixtures might give profit-
able effects. It is interesting to note that the addition of the phosphate, nitrate and potash together showed a most distinct gain. The ammonium sulfate alone gave the largest increase for any individual material, just as noted in the previous groups of plots. The phosphates did not show as large gains as in the other tests. The results as a whole, however, may be considered as evidence of the possibility of certain fertilizers being applied to pastures with profit. Further studies and field tests are certainly very desirable.

GENERAL CONCLUSIONS

Considering the results of these studies as a whole some conclusions are quite permissible. The desirability of dicing, reseeding and manuring or fertilizing old bluegrass pastures is very definitely shown. Perhaps the effects of dicing with reseeding may be considered most evident and these practices are very desirable. Manuring in addition also increases yields, but it must be noted that on most farms little or no manure is available for permanent pastures unless the supply for cultivated land is cut down to a low point. The use of commercial fertilizers may also often prove of large value and tests of various materials, particularly of acid phosphates, are urged. Where manure cannot be used it seems that commercial fertilizers are more certainly needed, but they may also give returns when used with manure. The character of the plant growth is frequently quite different where fertilizers are used and while the yields as shown in the figures given in this report were not increased to a large extent in some instances, there was often a large growth of the more desirable plants such as the legumes. The soluble nitrogenous materials seemed to stimulate the bluegrass growth to a considerable extent and in the early part of the season the growth of dandelions on the nitrogen plots was much reduced. The soluble phosphate seemed to be of particular value on the young clover and gave the largest effect on reseeded unmanured land.

The economic value of such a method of handling an old bluegrass pasture as practiced in this experiment may readily be figured, but calculations are not made in this report owing to the fact that only one year's results are given. The yields should be secured for several years before the results are figured on an economic basis.

It may be said, however, that the dicing, reseeding, manuring and some of the commercial fertilizer treatments gave profitable net returns when these are calculated from these 1923 results. When the hay crop is valued at $12 per ton dicing showed a net return of about $2.00 per acre; reseeding and dicing, about $6.00; manuring and dicing, $4.00; manuring, reseeding and dicing, $15.00; reseeding, dicing and the use of acid phosphate, $29.00; reseeding, dicing and the addition of sodium nitrate, $16.00; manuring, dicing and applying acid phosphate, $3.00 and other combinations of treatments also gave net returns.

As a whole, the results given in this circular indicate that old bluegrass pastures may be improved and kept in good condition by dicing, reseeding, manuring and proper fertilization. By these various treatments, profitable returns may often be secured in the way of a larger and better growth of pasture grasses and legumes and more feed for livestock may be secured. It is especially recommended that tests be carried out on blue grass pastures in all sections of the state to determine the value of dicing, reseeding, and the annual application of about 150 pounds of acid phosphate. This recommendation is based on the proven value of these three soil treatments and on the added fact that altho manure is a very valuable fertilizer for pastures, this material is not generally available even in moderate amounts, for use on the pastures of the state.