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# Pasture top-dressing in New Hampshire, Bulletin, no. 320

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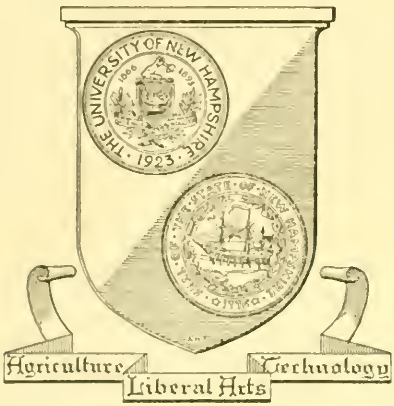


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Station Bulletin 320 April, 1940

# PASTURE TOP-DRESSING IN NEW HAMPSHIRE


An explanation of these plots is given on inside front cover

*by* F. S. Prince, G. P. Percival, P. T. Blood *and* P. N. Scripture

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**NP**—Nitrogen-phosphoric acid treatment. Note lack of clover in stand. Yields secured by clipping have been approximately the same as from plots treated with nitrogen-potash, but the grass is less palatable and less closely grazed.

**NK**—Nitrogen-potash treatment, a well-balanced sod with both clover and grass, and very closely grazed.

**NPK**—Nitrogen-phosphoric acid-potash treatment gave the highest yields with about the same balance between grass and clover as the nitrogen-potash treatment.

# Pasture Top-Dressing in New Hampshire

SINCE 1929 the New Hampshire Experiment Station has been conducting experiments in old pastures to see what improvement can be expected there from the application of lime and various fertilizer materials. This work has been predicated on the conviction that the low acre carrying capacity of New Hampshire pastures is due primarily to the exhaustion of available plant food through years of pasturing. Milk and livestock carrying plant food taken from these pastures have been sold off the farm with no replacement of the various elements that have been removed from the soil.

That this conviction is true has been borne out by the results secured. Experiment Station Circular 35, (February 1931) discussed in detail the response secured in ten old pastures scattered over five New Hampshire counties. While the results varied somewhat from pasture to pasture with soil type, the original vegetation in the sod, and particularly with the ability of the soil to retain moisture, the response secured indicated that all the pastures gave increased yields due to one or more of the top-dressing substances applied and that the response secured from superphosphate, potash or nitrogen could be rather accurately predicted.

This prediction could be based upon the presence or absence of wild white clover in the stand. If wild white clover was present or could be induced by fertilization to grow and spread in a short time, the sward responded more to superphosphate, potash and lime. If clover did not appear in the stand the chief response came from nitrogen.

Because of the interest in pasture improvement in New Hampshire at the present time, and since lime, superphosphate and potash are available to farmers under the Agricultural Conservation Program for pasture and crop land improvement practices, it seems pertinent to present again the data from these tests to indicate the relative response that may be expected from these different substances when used for pasture improvement.

TABLE 1—*Average yields on 10 pastures in 1930*

| | Pounds per acre | | | Pounds per acre | |
|---|---|---|---|---|---|
| Treatment | Dry matter | Protein | Gain for | Dry matter | Protein |
| LNPK | 2518 | 412 | N | 898 | 158 |
| LPK | 1620 | 254 | K | 231 | 49 |
| LP | 1389 | 205 | L | 234 | 42 |
| P | 1155 | 163 | P | 288 | 45 |
| Ch. | 867 | 118 | | | |

In the tests covered by tables 1—3 inclusive, the check plot was untreated, superphosphate (P) was applied at the rate of 600 pounds of 16 per cent to all treated plots, once in three years, potash (K) was used at the rate of 200 pounds of 50 per cent muriate once in three years, one ton of lime was top-dressed once in five years and nitrogen in the form of nitrate of soda was applied at 312 pounds annually.

TABLE 2.—*Average yields on 5 clover pastures, 1930*

| | Pounds per acre | | | Pounds per acre | |
|---|---|---|---|---|---|
| Treatment | Dry matter | Protein | Gain for | Dry matter | Protein |
| LNPK | 2862 | 458 | N | 546 | 58 |
| LPK | 2316 | 400 | K | 514 | 117 |
| LP | 1802 | 283 | L | 409 | 74 |
| P | 1393 | 209 | P | 444 | 83 |
| Ch. | 949 | 126 | | | |

Table one gives the average yield of the ten pastures for the season of 1930. The data indicate that all treatments increased yields, the yield of the complete fertilizer and lime plots running about three times that of the untreated checks. Gains for the various substances used alone or in combination show about equal response in the gains of both dry matter and protein in respect to superphosphate, lime and potash but considerably more stimulation for the nitrogen application.

TABLE 3.—*Average yields on 5 grass pastures, 1930*

| | Pounds per acre | | | Pounds per acre | |
|---|---|---|---|---|---|
| Treatment | Dry matter | Protein | Gain for | Dry matter | Protein |
| LNPK | 2173 | 367 | N | 1250 | 258 |
| LPK | 923 | 109 | K | —52 | —18 |
| LP | 975 | 127 | L | 59 | 11 |
| P | 916 | 116 | P | 130 | 11 |
| Ch. | 786 | 105 | | | |

A critical study of the vegetation in these pastures showed that some of them had a great deal of wild white clover during 1930 while others had very little or none apparent in the stand. Since the responses in the pastures differed widely depending upon the presence or absence of clover the pastures were divided and summarized on this basis.

The average yields of the five pastures in which clover was an integral part of the stand are given in Table 2. Increase in dry matter recorded for the various substances varies from 409 pounds per acre for lime to 546 pounds for nitrogen while increase for protein varies from 58 pounds for nitrogen to 117 pounds for potash. Potash presents a somewhat higher increase of protein, probably because it seems to exert a strong influence on clover. It should be noted in all these observations, however, that with the exception of superphosphate (P) none of the substances were used alone but with the other materials as indicated. Oftentimes the combined effect of two elements when used together is greater than when the two elements are used separately and the separate increases added together.

Table 3 is composed of an average of the remaining five pastures in which little or no wild white clover appeared in 1930. A slight increase is noted for superphosphate and lime, but potash failed to exert any influence on yields. Nitrogen, however, gave a splendid increase in both dry matter and protein, the total yield of dry matter of the LNPK plots running almost three times that of the check plot while the protein was more than tripled over the untreated check plots.

A critical examination of the soils of these pastures at the time indicated that it was the heavier soils in which white clover developed while the lighter soils, those of a sandy nature, were not conducive to the establishment of wild white clover. This would indicate that the better moisture relationship of the heavier soils is necessary for ideal pasture sods in which wild white clover forms an integral part. It is worth while to point out that acidity did not appear to be the prime factor in determining the presence of clover although liming increased foliage growth.

Because of the interest that has developed in pasture improvement in New Hampshire due to the Agricultural Conservation Program as well as to the land use programs, these data have been again presented although they had previously been published in part in Station Circular 35. They emphasize, for those who wish to start a system of pasture improvement, the need to select a well-watered or moisture-retentive soil, and indicate the return that may conceivably be expected from the use of lime and superphosphate or other materials likely to be used in bringing about the desired improvement.

During the season of 1931 some of these outlying pastures were continued and others added. Although the relative yield responses do not differ widely from those discussed, they are presented here as additional information.

Three of the pastures in Tables 4 and 5 were started in 1929, four were begun in 1930 and the other was laid out in 1931. In other words lime, superphosphate and potash were applied only once in the years stated, while nitrogen was applied annually.

TABLE 4.—*Average yields in 5 clover pastures, 1931*

| | Pounds per acre | | | Pounds per acre | |
|---|---|---|---|---|---|
| Treatment | Dry matter | Protein | Gain for | Dry matter | Protein |
| LNPK | 2873 | 561 | N | 669 | 135 |
| LPK | 2204 | 426 | K | 560 | 125 |
| LP | 1644 | 301 | L | 175 | 28 |
| P | 1469 | 273 | P | 418 | 106 |
| Ch. | 1051 | 167 | | | |

The clover pastures, as Table 4 indicates, responded to all the materials, the gain from the lime application being somewhat less than for the other substances. Here again the average yield of the complete fertilizer and lime plots is almost three times that of the

TABLE 5.—*Average yields in 3 grass pastures, 1931*

| | Pounds per acre | | | Pounds per acre | |
|---|---|---|---|---|---|
| Treatment | Dry matter | Protein | Gain for | Dry matter | Protein |
| LNPK | 1716 | 354 | N | 572 | 151 |
| LPK | 1144 | 203 | K | —19 | 22 |
| LP | 1163 | 181 | L | 123 | 9 |
| P | 1040 | 172 | P | 231 | 56 |
| Ch. | 809 | 116 | | | |

untreated plots while the protein values are somewhat wider than this.

The grass pastures, Table 5, again exhibited a tremendous stimulation from nitrogen, although in 1931 the plots treated with superphosphate alone showed up to a little better advantage than the grass pastures of 1930. (Table 3). It may be well to point out that the season of 1931 had considerably less rainfall than in 1930 which doubtless accounts for lower relative yields on these lighter soils in 1931, since these are the first to suffer in a dry season.

It can be readily seen, however, from a study of these brief tables that the type of sward that develops under fertilization will in large measure govern the response secured from the different materials. Nitrogen showed good response on all these pastures in both years. Whether a farmer should use nitrogen will depend upon whether he needs more feed in the spring since the stimulation from this element, applied early, will be secured mainly in May, June and early July. Of course there is a possibility of using nitrogen fertilizers later in the season and while the total response might not be as great it might still prove to be profitable if a serious feed shortage existed on the farm in the summer or fall.

The tables show also that returns from superphosphate, potash and lime are likely to be governed by the presence or absence of clover in the sward. Clovers respond more generously than do the grasses to these substances while grasses are especially responsive to nitrogen.

No tillage operations were practiced in these pastures and no seed was sown. The vegetation that was there or that developed under the various fertilizer procedures included the native grasses, Kentucky bluegrass, bent grasses, poverty grass, and other indigenous plants along with wild white or native pasture clover. Vegetative counts that were made on the plots during the time of their operation showed a distinct change from poverty grass and weeds to the better pasture types, Kentucky bluegrass and wild white clover, due to the rapid spread of these species at higher fertility levels. This change was surprisingly rapid amounting to 50 per cent or more in the course of one growing season.

In selecting these pastures at the outset, an attempt was made to choose as uniform a section of each one as possible and to get an area free from brush so that it would be feasible to mow small sections of each plot at intervals to check yields. The ground where the plots were located in each case was, therefore, covered with vegetation of one kind or another but should probably not be compared with trials where brush and shrubs would need to be cut before improvement could begin. In other words, the pastures covered by these tests were average open New Hampshire pastures, the dry matter yields indicating that they would carry about one cow to each five acres, untreated. Under treatment this carrying value was increased to about one cow to each one and one-half acres on the heavily fertilized plots with the other values ranging between these two figures.

The most pertinent question that can be asked in respect to work of this sort is, "Will top-dressing pay?" This question was answered in the publication previously mentioned in that all the fertilizer treatments on the clover pastures returned about two dollars' worth of feed for each dollar invested in materials. This statement also holds true for the complete fertilizer and lime treatment on the grass pastures. These statements refer to the average of the pastures concerned, and would of course have to be modified for the individual pastures in which case the returns might run considerably more or less than the averages quoted.

More extensive top-dressing experiments were laid out in 1932 in the Seavey pasture, Stratham and in 1933 in the Livingston pasture, Claremont, New Hampshire.

A preliminary report of these two experiments was included in Station Circular 48, April, 1935, in which the results secured up to and including the season of 1934 were discussed.

These tests have been continued, with certain modifications, and it is our purpose in this publication to present and discuss the results of this work up to the end of the 1939 pasture season.

The Seavey pasture is located in the edge of the town of Stratham. While there is no soil survey of this area, the soil concerned has been identified by soil survey men as belonging to the Charlton series, although the texture of both surface and subsoil permit somewhat better drainage than this same soil series in the Connecticut Valley counties. Because of this factor the soil would probably not be considered ideal for pasture since wild white clover does not form a uniform and integral part of the sward even under optimum fertilizer practice.

In contrast to Seavey, the Livingston pasture soil belongs to the Sutton series. The imperfect drainage of this series makes for a well watered soil, one in which wild white clover develops to a maximum if its fertility requirements are met. On plots treated with superphosphate and potash, this species assumes as much as 75 per cent of the vegetation in the sward and even when fertilized with a complete fertilizer having a 1-2-2 ratio wild white clover quickly assumes at least 50 per cent of the proportion of the vegetation. These facts apparently help to explain the relative responses from various fertilizer ingredients on these two fields.

Both these fields have in the past been cultivated, although the Livingston field, because of imperfect drainage, has been used as a pasture for many years. The Seavey field has more recently been under cultivation although the herbage in the stand has pretty well progressed to the native species, particularly Kentucky bluegrass.

Junipers at least eight or ten years old were cut on part of the area during the course of the test, although in the main the plots were well sodded over, and free from brush.

### A Comparison of Different Levels of Nitrogen

In both these pastures, a comparison was made between 25 and 50 pounds of nitrogen per acre annually, from nitrate of soda, with no other fertilizers.

TABLE 6.—*Seven year average yield, Seavey pasture*

| | | Pounds per acre | | Gain over check | |
|---|---|---|---|---|---|
| Plot No. | Treatment | Dry matter | Protein | Dry matter | Protein |
| 8 | Nitrate of soda, 312 lbs. | 2449 | 453 | 709 | 193 |
| 7 | Nitrate of soda, 156 lbs. | 2217 | 371 | 477 | 111 |
| 2-9-16 | Ave. yield check plots | 1740 | 260 | —— | —— |

Using dry matter and protein both as guides the lighter application of nitrogen increased yields more per unit of nitrogen applied than the heavier application. The 25 pound application increased yields 477 pounds of dry matter and 111 pounds of protein while the second increment of 25 pounds in the 50 pound amount returned but 232 pounds of dry matter and 82 pounds of protein.

Yields for these treatments in the Livingston pasture (Table 7) follow the same general trend, the lighter application giving slightly better returns per unit of nitrogen applied, the actual figures being 402 pounds dry matter and 100 pounds of protein and 267 pounds dry matter and 81 pounds protein, respectively, for the light and heavy applications.

TABLE 7.—*Five year average yield, Livingston pasture*

| | | Pounds per acre | | Gain over check | |
|---|---|---|---|---|---|
| Plot No. | Treatment | Dry matter | Protein | Dry matter | Protein |
| 2 | Nitrate of soda, 312 lbs. | 2339 | 437 | 669 | 181 |
| 7 | Nitrate of soda, 156 lbs. | 2072 | 356 | 402 | 100 |
| 1-8-14 -19-27 | Ave. yield check plots | 1670 | 256 | —— | —— |

The feeding value of the forage produced with nitrogen alone has been somewhat better on the Seavey than on the Livingston pasture. The sward on the Seavey nitrogen plots is composed mainly of Kentucky bluegrass while on the Livingston pasture sedges and other weeds appear which are less palatable than bluegrass. For this reason the Livingston plots under nitrogen treatment have not been so closely grazed as those of Seavey. Unfortunately, our method of clipping caged plots to determine yields does not permit any separation of desirable and undesirable species and for this reason Livingston nitrogen-yield increases are probably higher than they should be although in the correct relative proportion.

### Nitrogen Fertilizers Compared

During the course of these two experiments, certain of the common nitrogen carriers have been used annually on different plots for comparison. These have all been used in equivalent amounts of nitrogen. 50 pounds of elemental nitrogen per acre.

Because of the difference in rate of availability various carriers have been applied at different times in the spring. To avoid burning the grass and because of its slightly slower availability cyanamid has been applied annually about April 1. while sulphate of ammonia has usually been spread about April 15. with the nitrate of soda and cal nitro applications around April 25. Variations in the time of application have been due to seasonal differences. In a very late spring for example, the actual time might be five or ten days later than the dates given. It has been felt that this difference in time might equalize the net effects of the materials so far as it is within the power of those who apply them.

Certain minor changes in treatment were made on some of the nitrogen plots on Livingston pasture in 1938 and on Seavey in 1939 so that we have a five-year average on Livingston and seven years' record on Seavey for these treatments. The average annual yields with check plot comparisons are presented in Tables 8 and 9. These are arranged in descending order according to yields of protein per acre.

Table 8.—*Seven year average yield, Seavey pasture*

| | | Pounds per acre | | Difference from check | |
|---|---|---|---|---|---|
| Plot No. | Treatment | Dry matter | Protein | Dry matter | Protein |
| 18 | Sulphate of ammonia, 250 lbs. | 2612 | 466 | 872 | 206 |
| 8 | Nitrate of soda, 312 lbs. | 2449 | 453 | 709 | 193 |
| 17 | Cyanamid, 250 lbs. | 2369 | 368 | 629 | 108 |
| 2-9-16 | Ave. yield check plots | 1740 | 260 | —— | —— |

Perhaps the most interesting point in connection with Tables 8 and 9 is that the sulphate of ammonia treatment stands first in Seavey and last in the Livingston pasture. It is a well-known fact that sulphate of ammonia increases soil acidity and this treatment is definitely inimical to clover. However, since very little or no clover appeared under any of the nitrogen treatments in either pasture, acidity alone can scarcely account for the differences secured. However, the grass in the two pastures looks very different after being top-dressed with sulphate of ammonia, that in the Seavey pasture looking entirely healthy, that in Livingston assuming a reddish hue shortly after treatment. This red color disappears later in the season but after its disappearance the foliage is darker than that of other nitrogen plots.

Nitrate of soda has given a good account of itself in both pastures, standing first in Livingston (Table 9) and running a very close second to sulphate of ammonia in Seavey (Table 8).

These data for nitrogen treatments are presented for the interest they bear and not because nitrogen alone is a recommended treat-

TABLE 9.—*Five year average yield, Livingston pasture*

| | | Pounds per acre | | Difference from check | |
|---|---|---|---|---|---|
| Plot No. | Treatment | Dry matter | Protein | Dry matter | Protein |
| 2 | Nitrate of soda, 312 lbs. | 2339 | 437 | 669 | 181 |
| 3 | Calcium nitrate*, 333 lbs. | 2084 | 394 | 414 | 138 |
| 4 | Cyanamid, 250 lbs. | 1937 | 372 | 267 | 116 |
| 6 | Cal nitro, 250 lbs. | 2037 | 362 | 367 | 106 |
| 5 | Sulphate of ammonia, 250 lbs. | 1844 | 352 | 174 | 96 |
| 1-8-14-19-27 | Ave. yield check plots | 1670 | 256 | —— | —— |

*After the third year this treatment was changed from calcium nitrate to cal nitro.

ment for pasture sods. It is not likely that a farmer would initiate a top-dressing system with nitrogen only, but would probably make a start with a complete fertilizer or even with superphosphate and potash before using nitrogen. And it is very likely that even small amounts of these other substances applied annually or moderate amounts applied every second or third year would serve to increase yields to some extent (as they have in the Livingston pasture) and their application might serve to change to some extent the relative rating of the materials in question.

## Home Mixed Fertilizers Compared

In Seavey pasture comparisons are available for various home-mixed fertilizers which include different nitrogen and phosphorus carriers. The mixtures used and the yields secured are given in Table 10, arranged in order of descending yields of protein.

TABLE 10.—*Seven year average yield, Seavey pasture*

| | | Pounds per acre | | Difference from check | |
|---|---|---|---|---|---|
| Plot No. | Treatment | Dry matter | Protein | Dry matter | Protein |
| 15 | Cal nitro, 250 lbs. annually<br>Basic slag, 555 lbs. every 3 yrs.<br>Muriate of potash, 200 lbs. 50% every 3 years | 2577 | 462 | 837 | 202 |
| 11 | Nitrate of soda, 312 lbs. annually<br>Superphosphate, 500 lbs. 20% every 3 years<br>Muriate of potash, 200 lbs. 50% every 3 years | 2521 | 462 | 781 | 202 |
| 14 | Cyanamid, 250 lbs. annually<br>Basic slag, 555 lbs. every 3 yrs.<br>Muriate of potash, 200 lbs. 50% every 3 yrs. | 2595 | 433 | 855 | 173 |
| 13 | 8-16-16, 625 lbs. every 3 yrs.<br>Cal nitro, 250 lbs. in other yrs. | 2458 | 432 | 718 | 172 |
| 12 | Nitrate of soda, 156 lbs. annually<br>Superphosphate, 167 lbs. annually<br>Muriate of potash, 67 lbs. annually | 2179 | 374 | 439 | 114 |
| 2-9-16 | Check plots ave. No treatment | 1740 | 260 | —— | —— |

The data in Table 10 are striking in that yields of the first four treatments are very close together. Perhaps this is not surprising as the same amount of plant food was applied to each plot, but the nitrogen alone results had shown rather wide differences for different nitrogen carriers.

The increase for the cyanamid, basic slag, muriate of potash combination is interesting in view of the relatively low response for the use of cyanamid alone (Table 8). When balanced with phosphoric acid and potash this treatment actually gave slightly higher dry matter yields than other "complete" fertilizer treatments and made a very good showing in protein increase. (It should be pointed out, however, that this material should not be mixed with other fertilizers in the amounts specified but should be applied separately. The same may be said of basic slag phosphate.)

With respect to these complete fertilizers one might almost conclude that so far as different materials are concerned it makes no difference what the source, so long as equal amounts of plant food are applied. This statement appears to be verified by results on the plot which had but 156 pounds of nitrate of soda annually, although this plot did receive equivalent amounts of superphosphate and potash, applied annually, and not in a large triennial application. The response secured under this treatment is in the same relative proportion as the half application of nitrate of soda. (Table 6).

Perhaps the most noteworthy thing about the figures from Seavey pasture may be brought out by comparing Tables 8 and 10, a study of which reveals how little stimulation has been secured from complete fertilizers over that from nitrogen alone. The average total yield from the four complete fertilizers has been 2538 pounds of dry matter and 447 pounds of protein per acre while the three nitrogens have yielded an average of 2476 and 429 pounds, respectively, of dry matter and protein. The differences between these values are not wide enough to be significant.

This similarity of response is due primarily to the soil and to its lack of ability to support a good stand of wild white clover with the grasses that are present. Wild white clover does appear in the plots to some extent, depending upon treatment, but in no plot does it assume the importance in the sward that it does in the Livingston pasture, where under treatment with phosphoric acid and potash wild white clover abounds.

Seavey pasture, in other words, is not unlike the grass pastures listed earlier in this publication and the Livingston pasture would certainly qualify as a clover pasture because of the importance of

Table 11.—*Five year average yield, Livingston pasture*

| | | Pounds per acre | | Difference from check | |
|---|---|---|---|---|---|
| Plot No. | Treatment | Dry matter | Protein | Dry matter | Protein |
| 9 and 16 | 8-16-16, 625 lbs. annually | 3543 | 641 | 1873 | 385 |
| 13 | Ammo Phos, 11-48-0, 200 lbs. Nitrate of potash, 13-0-44, 220 lbs. | 3469 | 663 | 1799 | 407 |
| 18 | Nitrate of soda, 156 lbs. Sulphate of ammonia, 125 lbs. 0-20-20, 500 lbs. | 3379 | 667 | 1709 | 411 |
| 1, 8, 14, 19 | 27 checks, no treatment | 1670 | 256 | —— | —— |

clover there when proper fertility conditions are maintained for its sustenance.

The responses for complete fertilizers in Livingston pasture are therefore proportionately higher than in Seavey as indicated in Table 11.

The treatments listed in Table 11 were all applied annually in contrast to the triennial superphosphate and potash application on most of the plots of Seavey pasture. This means, of course, that three times as much phosphoric acid and potash have been applied on Livingston as on the Seavey plots. Unless one had seen the plots to observe how they react this might lead to the conclusion that these heavier applications would be responsible for the differences in amount of clover on the two fields. The response in clover is so distinct and immediate on the Livingston field after superphosphate and potash are applied that the difference cannot be accounted for in this manner. Rather it must be due to slower availability of one or the other of the elements on Livingston, coupled with the better moisture relations of the soil, which, when conditions are right, permit maximum crops of wild white clover.

A comparison of Tables 9 and 11 indicates how much better Livingston pasture responds to complete fertilizer than to nitrogen alone. The maximum yields of dry matter and protein with nitrogen are 2339 and 437 pounds, respectively, whereas the top treatments with complete fertilizers returned 3543 pounds of dry matter and 667 pounds of protein per acre, an increase of more than 50 per cent.

The average yields of all nitrogen plots and of all complete fertilizer plots of Livingston pasture are presented here for comparison:

TABLE 12.—*Five year average yield, Livingston pasture*

| | Pounds per acre | | Gain over check | |
|---|---|---|---|---|
| Treatment | Dry matter | Protein | Dry matter | Protein |
| 50 lbs. nitrogen per acre annually | 2048 | 383 | —— | —— |
| 50 lbs. nitrogen with 100 lbs. each of $P_2O_5$ and $K_2O$ annually | 3391 | 632 | 1343 | 249 |

The gain represents an increase of 65 per cent for the complete over the nitrogen treatment. It should be remembered here that equal quantities of nitrogen were applied in all cases.

## Fertilizers Without Nitrogen

A rather elaborate system of top-dressing with superphosphate and potash has been conducted on Seavey while on Livingston pasture only a limited amount of work in this respect has been done.

Table 13 gives the yields for various phosphoric acid and potash treatments on Seavey pasture, alone, and in combination.

Basic slag, Plot 1, has proved to be a better carrier of phosphoric acid than superphosphate in this test, either because the phosphoric acid from this compound holds its availability for a longer period or

TABLE 13.—*Seven year average yield, Seavey pasture*

| | | Pounds per acre | | Difference from check | |
|---|---|---|---|---|---|
| Plot No. | Treatment | Dry matter | Protein | Dry matter | Protein |
| 1 | Basic slag, 555 lbs., 3 yrs. | 1924 | 323 | 184 | 63 |
| 3 | Superphosphate, 500 lbs. 20%, 3 yrs. | 1724 | 295 | —16 | 35 |
| 4 | Superphosphate, 167 lbs. 20% annually | 1693 | 283 | —47 | 23 |
| 5 | Muriate of potash, 200 lbs. 50%, 3 yrs. | 1711 | 291 | —29 | 31 |
| 6 | Muriate of potash, 67 lbs. 50% annually | 1839 | 312 | 99 | 52 |
| 10 | Superphosphate, 500 lbs. 20%, 3 yrs. Muriate of potash, 200 lbs. 50%, 3 yrs. | 2276 | 396 | 536 | 136 |
| 2, 9, 16 | Checks, no treatment | 1740 | 260 | —— | —— |

because it carries lime, or both. Dry matter produced from superphosphate is not quite equal to the check-plot yield either in the large triennial application or in the smaller annual one although protein values for both are higher than for the checks. The triennial application of superphosphate has given slightly better yields than the smaller annual applications, while with the potash applications the reverse is true. It is doubtful, however, if the differences are significant, nor would a farmer be justified in making the smaller applications annually, if labor costs were a factor.

Perhaps the most interesting thing about Table 13 is the rather large increases in both dry matter and protein when superphosphate and potash were applied together, (Plot 10). It is probably the rule, rather than the exception, that when these two materials are applied together, the net increase is greater than when they are applied separately. Certain it is, that in this case, fertilizer balance is very important.

It should be pointed out also that the increase for superphosphate and potash applied together has made a very substantial showing on Seavey pasture when it is considered that complete fertilizers did not materially increase yields over nitrogen alone. This would appear to lead to the conclusion that the heavy grass growth produced by nitrogenous fertilizers is definitely inimical to clover growth on this soil, under the conditions of pasturing that prevail. Since the field is not always stocked to its maximum capacity, this is probably true, whereas the same condition would not hold on a pasture which was evenly and closely grazed at all seasons of the year. In Livingston pasture where clover comes in greater profusion than on Seavey, the field is generally quite closely grazed and it has not been felt that nitrogen in complete fertilizers inhibited clover growth so that summer pasture yields were seriously reduced.

Several treatments that have been included on Livingston pasture do not fit into the categories previously discussed. These include annual applications of 0-20-20, 12-4-4, Ammo Phos 11-48-0 and nitrate of potash, 13-0-44.

The results from these fertilizers are summarized in Table 14.

TABLE 14.—*Five year average yield, Livingston pasture*

| | | Pounds per acre | | Difference from check | |
|---|---|---|---|---|---|
| Plot No. | Treatment | Dry matter | Protein | Dry matter | Protein |
| 10 | 12-4-4, 417 lbs. per acre | 2364 | 390 | 694 | 134 |
| 12 | 0-20-20, 500 lbs. per acre | 2529 | 499 | 859 | 243 |
| 15 | Ammo Phos, 11-48-0, 455 lbs. per acre | 2439 | 502 | 769 | 246 |
| 17 | Nitrate of potash, 13-0-44, 380 lbs. per acre | 2687 | 514 | 1017 | 258 |
| 9, 13, 16, 18 | Ave. 3 complete fertilizers (in Table 11) | 3464 | 657 | 1794 | 401 |
| 2, 3, 4, 5, 6, 26, 28 | Ave. 5 nitrogen carriers (in Table 9) | 2048 | 383 | 378 | 127 |
| 1, 8, 14, 19, 27 | Check, no treatment | 1670 | 256 | —— | —— |

Included in Table 14 are average responses from four complete fertilizers and five nitrogen carriers for comparison. Plot 10, which received 50 pounds of nitrogen in a 12-4-4 fertilizer increased yields but little over the average nitrogen carrier. Although this fertilizer contains a limited amount of phosphoric acid and potash, the amount of these two elements contained therein is not sufficient to induce anything like maximum clover growth such as is obtained under the 0-20-20 treatment in Plot 12 or even with the complete fertilizers.

There is but one comparison available on Livingston field for a fertilizer without nitrogen. This is Plot 12, where a 500 pound application of 0-20-20 was annually applied. The yield of this plot for the period studied is about midway between the average of the nitrogen and complete fertilizers. This is, of course, in direct contrast to Seavey where the phosphoric acid-potash treatment is considerably below both the other treatments.

One interesting thing about the 0-20-20 treatment lies in the fact that the forage there has a higher protein content than that of any other treatment. This reflects the higher percentage of clover which appears under this treatment, a larger percentage even than with a complete fertilizer system.

On Plot 15, Ammo Phos A, 11-48-0, has been used while on Plot 17, nitrate of potash 13-0-44 has been annually applied. These two fertilizers have been applied at rates so that 50 pounds of elemental nitrogen would be furnished. While the actual yields for the two plots are not vastly different (Table 14) wild white clover has appeared in abundance on the plot treated with nitrate of potash, whereas there has been very little clover to date on the Ammo Phos plot. Moreover, the nitrate of potash plot has been very closely grazed while the forage produced with the Ammo Phos treatment has been distinctly less palatable and less closely fed.

Ammo Phos has a distinct tendency to make the soil more sour which may militate to some extent against the clover. But above this the grass on this plot has assumed a reddish hue similar to that on which sulphate of ammonia was applied. Under grazing tests the Ammo Phos plot would certainly show a distinct disadvantage when compared with nitrate of potash on this soil. Unfortunately the method of harvesting that has been practiced in this experiment does not take palatability into account as would the cows under actual grazing trials, since with a lawn mower we clip everything, palatable or unpalatable, and include it in the yields.

### Change of Treatment on Livingston Plots

Six of the Livingston plots which for five years had been receiving nitrogen alone were divided in the spring of 1938 and since then one end of each plot has had 200 pounds of an 0-20-20 annually, the other 600 pounds of an 0-20-20 in what is designed to be a triennial application. Thus, in Table 15, one series has had a total of 400 pounds of an 0-20-20 in a divided application while the other has received 600 pounds at one treatment. The amounts of phosphoric acid and potash applied are therefore not yet equal but the data are presented to indicate how quickly this soil responds to these minerals. The nitrogen applications were continued during this period. Other plots receving nitrogen alone during the same period are shown for comparison so that all data are for the same years.

TABLE 15.—*Two year average yield, Livingston pasture*

| | Pounds per acre | | Difference from nitrogen | |
|---|---|---|---|---|
| Treatment | Dry matter | Protein | Dry matter | Protein |
| Nitrogen only | 2559 | 425 | —— | —— |
| Nitrogen + 200 lbs. 0-20-20 ann. | 3778 | 665 | 1219 | 240 |
| Nitrogen + 600 lbs. 0-20-20, 3 yrs. | 4282 | 701 | 1723 | 276 |

In this table the two 0-20-20 treatments with nitrogen have been compared directly with the nitrogen alone plots. The increases recorded for the annual application of 200 pounds of 0-20-20 are 48 per cent higher than nitrogen alone for dry matter and 56 per cent higher for protein while the 600 pound application runs 67 and 65 per cent higher for these two substances, respectively.

Even more interesting than the data is the rapidity of the change in vegetation which occurred in the plots themselves, after applying the fertilizer containing phosphoric acid and potash. Within a few weeks wild white clover appeared, and by midsummer of the first season the vegetation there was mixed grass and clover where very little or no clover had occurred before under the previous nitrogen treatments.

### Effect of Rainfall on Pasture Production

It has been interesting to note the variation in pasture yields from season to season on these two experimental fields. Rainfall always varies, of course, and since no attempt is made to water these pastures artificially the differences that occur in productivity in different seasons for the same treatments are governed largely by the amount and distribution of summer rainfall.

The summer season of 1938 was very wet and that of 1939 was quite dry. The rainfall data in Table 16 are taken from records secured at the Livingston farm, and from the Ireland farm which is less than two miles distant by air line from Seavey pasture.

TABLE 16.—*Rainfall records, seasons of 1938 and 1939*

| | LIVINGSTON FARM | | | | IRELAND FARM | | | |
|---|---|---|---|---|---|---|---|---|
| | 1938 | | 1939 | | 1938 | | 1939 | |
| | Days of rain | Total per mo. | Days of rain | Total per mo. | Days of rain | Total per mo. | Days of rain | Total per mo. |
| April | 8 | 2.57 | 5 | 1.27 | 11 | 3.09 | 8 | 4.55 |
| May | 8 | 2.73 | 5 | 1.73 | 10 | 3.98 | 6 | 1.80 |
| June | 7 | 2.17 | 7 | 1.93 | 8 | 5.20 | 7 | 2.12 |
| July | 9 | 7.89 | 6 | 1.56 | 10 | 9.75 | 4 | .77 |
| August | 6 | 3.06 | 8 | 4.37 | 5 | 2.10 | 6 | 4.58 |
| Sept. | 7 | 9.43 | 8 | 3.81 | 6 | 7.17 | 4 | 1.72 |
| Totals 6 mo. | 45 | 27.85 | 39 | 14.67 | 50 | 31.29 | 35 | 15.54 |

These records show that the 1938 precipitation for the months in question was approximately double that for 1939.

The average yields of the nitrogen alone, complete fertilizer and check plots for both pastures are given in Table 17 for these two seasons:

TABLE 17.—*Pasture yields, 1938 and 1939, Livingston and Seavey farms*

| LIVINGSTON PASTURE | | | | | | |
|---|---|---|---|---|---|---|
| | 1938 | | | 1939 | | |
| Treatment | Dry matter | % of protein | Protein | Dry matter | % of protein | protein |
| | lbs. | | lbs. | lbs. | | lbs. |
| Nitrogen alone, ave. | 3202 | 15.4 | 492 | 1916 | 18.7 | 359 |
| Complete fertilizers, ave. | 5066 | 17.5 | 885 | 3700 | 19.1 | 708 |
| Check | 2800 | 13.8 | 386 | 1537 | 15.9 | 245 |
| SEAVEY PASTURE | | | | | | |
| Nitrogen alone (ave. of all) | 3393 | 16.3 | 552 | 2522 | 17.5 | 442 |
| Complete fertilizer (ave. of all) | 4421 | 17.0 | 751 | 2562 | 19.0 | 488 |
| Check plot (averages of all) | 2983 | 15.5 | 461 | 1672 | 15.7 | 263 |

It is a well-known fact that pastures are much more productive in wet seasons than in dry ones, and this difference in productivity is reflected in Table 17. On the Livingston pasture the difference amounts to about 1300 pounds of dry matter per acre for each treatment, on the average, while on Seavey the difference varies from about 800 pounds dry matter per acre on the nitrogen plots to almost 1900 pounds on the complete fertilizer plots, with the check plot differences averaging about 1300 pounds per acre.

The comparison between nitrogen alone and complete fertilizer on Seavey pasture for the wet season of 1938 is interesting in that this is the only year in the duration of the test when the complete fertilizers greatly outyielded the nitrogen treatments, the difference amounting to 1028 pounds of dry matter and 199 pounds of protein per acre. In 1939, however, the dry matter yields were almost identical, with a difference of but 40 pounds in dry matter although 46 pounds more protein were produced on the complete fertilizer plot. The increased protein in the forage produced with complete fertilizer is doubtless due to a greater proportion of clover on these plots.

Whereas yields during the wet season of 1938 were notably higher than those of 1939, the percentage of protein* in the forage was significantly higher during 1939 than in 1938. The differences for the various averages given vary all the way from two-tenths of one per cent on the Seavey check plots to as much as 3.4 per cent on the nitrogen alone plots of Livingston pasture.

While it is impossible to control rainfall and as yet no one has attempted any sort of pasture irrigation in New Hampshire, these wet and dry season data are interesting since they indicate that with heavier rainfall pastures would be considerably more productive. Presumably, in earlier years, pastures were more productive because, after the forests were cleared, there was much organic matter in the surface soil to hold moisture and yield it to pasture crops during the growing season. As the years have gone by and as the sod in pastures has become thinner, this original supply of organic matter has probably become depleted so that these soils are not as retentive of moisture as once they were. This would account for more serious effects of drought than formerly and at the same time limit the possibility of having much wild white clover in many pasture swards.

It would be impossible, of course, for most farmers to irrigate their pastures. But there are probably a good many dairymen in the state whose pastures are near an unfailing water supply that could be used during the hotter and drier portions of the summer. If the yields of the pasture could be increased by one-half ton of dry matter per acre, it might well prove profitable since that amount of feed will supply the forage needs of one cow for more than a month.

Contour furrowing is another means of water conservation which is as yet unexplored in New England pastures. This method, which consists of plowing furrows on contour to establish ridges which will hold back the water that would otherwise run off, may be a means of conserving moisture and improving pasture yields, although the number of pastures in the state that would lend themselves to such a method would necessarily be rather limited when compared with the total pasture acreage.

Because of its moisture relationship, the organic matter of the soil of the pasture is felt to be of much importance. Most of the present supply is in the surface soil and in some of the newer pastures more recently cleared from woods it is likely to be most abundant in the upper two or three inches. Plowing usually turns this high organic layer deeper into the soil and may leave a surface with a much lower organic content than before. Since most permanent pasture plants are relatively shallow rooted, plowing may result in a disadvantage to them. Plowing is expensive in most instances, even in tillable pastures, and since lime and fertilizers must be used anyway it may often be preferable merely to top-dress rather than to

*Protein—N x 6.25

plow and reseed. This will be especially true unless a heavy application of manure can be incorporated with the surface soil to build up the organic supply there.

### Is Pasture Improvement Profitable?

In previous reports, (Experiment Station Circulars 35 and 48) an effort was made to evaluate the economy of pasture improvement. In Circular 35 it was noted that, "Feed can be produced in good pastures by judicious fertilization at one half or less of its cost in a mixed dairy feed." In Circular 48 it was stated, "Data are presented indicating that from two to eleven times as much feed has been produced in these pasture trials with fertilizers as an equivalent amount of money would purchase at the feed store." In general, in both these publications it was noted that the better the pasture, the more likely a profitable response would be secured. Further, that pastures with wild white clover were much more responsive to materials other than nitrogen and that the presence of clover would in large measure influence the economy of use of these materials.

An attempt has been made to calculate the returns per acre that have actually been received from using different fertilizer practices in Seavey and Livingston pastures. In arriving at these calculations certain assumptions have to be made relative to the work, since increases have been measured in harvested yields rather than in milk produced. This we know is relatively true although not absolutely so, since one instance has been cited of unpalatability that developed under a certain treatment which probably prevented the cows from using as much of the grass as our harvests would appear to indicate. Further, it is assumed that the feeding constituents of the dry matter of the grass bear a certain definite relationship to feed that would have to be purchased in other forms. The values herein have been calculated on the basis of grain prices at $30 per ton, which is about 80 per cent of present costs. Although, as stated, this value is assumed, it is thought to be fair in view of experimental work which has been done with dried young pasture forage. Camborn,[1] for example, reports that, "On the basis of total digestible nutrients consumed, the dried grass ration was apparently at least equal to or possibly very slightly more efficient than the grain ration." Our method of calculation would therefore seem to be conservative.

In the summaries that follow calculations have been made for most of the treatments. So far as possible average values have been used instead of results for individual treatments so that the results for nitrogen and for complete fertilizers appear together. This has been done merely for conciseness. Present values have been used in considering fertilizer costs as nearly as these can be obtained.

This summary brings out in a financial way the facts that have been stated previously concerning the responses for various treatments. The net annual returns per acre which are presented in the last column of Table 18 were obtained by subtracting the cost of the fertilizer from the gain over the check plots in value of forage pro-

[1] Camborn, O. M. Vermont Bulletin 359, June, 1933.

TABLE 18.—*Financial returns, Seavey pasture, per acre per year*

| Treatment | Value of forage | Gain over check | Cost of fertilizer | Net annual return per acre |
|---|---|---|---|---|
| Basic slag, 555 lbs., 3 yrs. | $24.22 | $ 4.72 | $2.05 | $2.67 |
| Superphosphate, 500 lbs. 20%, 3 yrs. | 22.12 | 2.62 | 1.70 | .92 |
| Superphosphate, 167 lbs. 20%, annually | 21.22 | 1.72 | 1.70 | .02 |
| Muriate of potash, 200 lbs. 50%, 3 yrs. | 21.82 | 2.32 | 1.16 | 1.16 |
| Muriate of potash, 67 lbs. 50%, ann. | 23.40 | 3.90 | 1.16 | 2.74 |
| Muriate of potash, 200 lbs. 50% } 3 yrs. Superphosphate, 500 lbs. 20% } | 29.70 | 10.20 | 2.86 | 7.34 |
| Ave. 3 nitrogen carriers, 50 lbs. N ann. | 32.18 | 12.68 | 6.00 | 6.68 |
| Ave. 4 complete fertilizers 50 lbs. N annually, 100 lbs. $P_2O_5$ and 100 lbs. $K_2O$ every 3 yrs. | 33.52 | 14.02 | 8.86 | 5.16 |

duced. All of the treatments increased production over and above the cost of the fertilizer varying from two cents per acre in the annual application of superphosphate to $7.34 in the triennial application of superphosphate and potash. In point of returns on the money invested the treatments rank as follows: superphosphate and potash, annual potash application, basic slag, nitrogen alone, triennial application of potash, complete fertilizers, triennial application of superphosphate and annual application of superphosphate.

It seems only fair to state in this connection, that farmers are not likely to grow enthusiastic about pasture improvement when it is impossible to see with the eye the results secured. On a pasture which responds as does this one it would take results such as are gained by applying nitrogen, complete fertilizers, or superphosphate and potash to accomplish this end.

TABLE 19.—*Financial returns, Livingston pasture, per acre per year*

| Annual treatment per acre | Value of Forage | Gain over check | Cost of fertilizer | Net annual return per acre |
|---|---|---|---|---|
| Ave. 5 nitrogen carriers, 50 lbs. N | $28.72 | $ 9.52 | $ 6.00 | $ 3.52 |
| 0-20-20, 500 lbs. | 34.72 | 18.22 | 10.00 | 8.22 |
| Ave. 3 complete fertilizers, 625 lbs. 8-16-16 | 49.28 | 30.07 | 15.29 | 14.78 |

Of the Livingston treatments, Table 19, complete fertilizers rank first in net returns per acre as well as returns per dollar invested. This is followed by the 0-20-20, with nitrogen third. Again it may be well to point out that phosphoric acid and potash were applied on Livingston pasture at a heavy annual rate, three times that of the Seavey plots, and it is quite possible that a lower rate of application might have affected appreciably the economy of operations although yields would doubtless have been somewhat lower.

These data are designed to contrast the purchase of feed, a well-known farm operation, with the purchase of fertilizer which is applied to pasture sods to increase the feed there. The latter is a less well established practice than buying feed but a very effective one since the fertilizer dollar in all cases brought in more than one dollar's worth of feed and in most instances two dollars' worth or more.

**Lime Results**

The pH value of Livingston pasture without lime varies from 5.6 to 6.0 and it has not been felt that lime would be particularly beneficial there, hence none has been used.

In Seavey pasture, however, which had a pH of about 5.2, lime was used at the outset at the rate of one ton, top-dressed on one-half of each plot except those that were to receive basic slag and cyanamid. It has not been possible, at any time, to detect with the eye the area on which this lime was spread, so imperceptible have been the results each year.

Over a period of eight years, however, the limed portions have slightly outyielded the unlimed sections and on the basis of the increase lime has more than paid its cost. In actual increase based on protein, the net return per acre each year has been $1.27 or $10.16 for the eight-year period. The fact that clover has not been as prominent in the vegetation as it is on many heavier pasture soils is believed to account in large measure for the rather low response for liming.

From time to time soil samples from the Seavey and Livingston plots have been tested for acidity as well as for available nutrients. Since lime was not introduced into the Livingston trials, acidity changes are due mainly to residual effects of fertilizers.

On Seavey pasture lime was used on one half of each plot with exceptions as stated. The lime was applied in the spring of 1932 and in November, 1934, soil samples were taken by two-inch levels to a depth of six inches on the halves of each plot. The tests for acidity are interesting since they indicate the pH changes in the soils due to lime and to the various fertilizers not only in the surface but in the second and third two-inch levels.

Tests for certain of these plots are arranged in Table 20:

TABLE 20.—*Soil pH values, Seavey plots*

| Plot No. | | 2, Ch | 3, P | 5K | 8PK | 10N | 11NPK | 18N |
|---|---|---|---|---|---|---|---|---|
| | | pH | pH | pH | pH | pH | pH | pH |
| Limed | 0-2" | 6.04 | 6.11 | 5.96 | 6.15 | 6.11 | 6.19 | 6.21 |
| | 2-4" | 5.52 | 5.52 | 5.52 | 5.88 | 5.60 | 5.64 | 5.41 |
| | 4-6" | 5.45 | 5.48 | 5.47 | 5.67 | 5.38 | 5.57 | 5.29 |
| Unlimed | 0-2" | 5.19 | 5.22 | 5.18 | 5.58 | 5.31 | 5.67 | 4.89 |
| | 2-4" | 5.12 | 5.17 | 5.23 | 5.61 | 5.27 | 5.65 | 5.03 |
| | 4-6" | 5.20 | 5.20 | 5.34 | 5.48 | 5.33 | 5.68 | 5.07 |

These tests show a considerable rise in pH value on the limed sections in the surface two inches, and a certain effect through the four and six inch layers. This may be contrary to current opinion which would lead us to believe that the effect of lime, top-dressed, is generally confined to the first two or three inches. In the data listed, the four and six inch layer has a higher pH in all comparisons except Plot 11 and out of 15 available comparisons the pH value is as high or higher for thirteen on the limed than on the unlimed sections.

## Top-Dressing Increases Protein

The protein content of the dry matter of the forage has been increased in this top-dressing work, no matter what the treatment. Table 21 states the percentage protein found in the different treatments of Seavey and Livingston pastures. The higher average protein of Livingston pasture as compared with Seavey probably reflects the greater percentage of clover that develops there, particularly under the PK treatment. These data are presented merely to indicate that dry matter alone is not an adequate criterion to determine feeding value.

Table 21.—*Per cent protein in dry matter of forage*

| Treatment | Seavey pasture Per cent protein | Livingston pasture Per cent protein |
|---|---|---|
| Ch | 14.9 | 15.3 |
| P | 17.1 | —— |
| K | 17.0 | —— |
| PK | 17.4 | 19.7 |
| N | 17.3 | 18.7 |
| NPK | 17.6 | 18.6 |

Furthermore, this protein increase undoubtedly favorably affects the palatability of the grass and accounts for the cows spending a greater amount of time feeding on treated than on untreated pasture, if they have a choice.

Another factor which doubtless has a bearing on the nutritional value of treated pasture grass is the increased mineral content. While the forage on these trials was not analyzed for its mineral content, such work has been done by a number of investigators. For example, Brown[1] reports, "The proportion of phosphorus (in the forage) was raised about 60 per cent, as an average for two years by an application of superphosphate. Potash treatments increased the amount of potassium in eleven of twelve comparisons. Calcium was increased apparently because of the prevalence of clover in the LP and LPK plots, while the omission of superphosphate in the LK plot resulted in a low percentage of calcium in the grasses present. Clover in the NPK plot also had a low percentage of calcium. Superphosphate alone increased calcium in clover and grasses as well. Magnesium varied directly with calcium while manganese in the forage was reduced by lime applications."

It is impossible to evaluate the effect of the increased mineral content of pasture herbage due to fertilization. That minerals are important no one can deny and the fact that most grain mixtures carry calcium and phosphorus in the form of limestone and bone meal is evidence of their need. Furthermore, it is generally conceded that these minerals in organic substance, such as pasture herbage, are more effective in animal nutrition than they are in other forms. This appears to lend much weight to the necessity of supplying minerals to infertile pastures to enhance the mineral value of the roughage itself.

[1]B. A. Brown, Am. Soc. Agron. Journal. Vol. 24. No. 2, February, 1932,

### Grazing Not Controlled

Grazing on these experimental areas in Seavey and Livingston pastures was not controlled. This fact may have led to some overgrazing of the better plots with perhaps some injury to the sod.

The plots are laid out side by side in the corner of a larger field, with the check plots scattered amongst the treated plots. The cows come into this area and feed heavily as the grass is better there than anywhere else in the field manuring all the plots indiscriminately, of course. Hence, we suspect that the check-plot yields tend to come nearer the yields of other plots than they would if the plots were fenced and grazing controlled on each treatment. There seems to have been no way to avoid this factor, however.

## Summary and Recommendations

Experimental results obtained by top-dressing fertilizers and lime on old pasture sods are presented in this bulletin.

The response of pasture sods to fertilizers and lime seems to be governed by the moisture relationships of the soil, the lighter, drier soils responding mainly to nitrogen while the heavier, moister soils respond to all the fertilizer nutrients and lime because wild white clover forms a component part of the sod on such soils under proper treatment.

Good sod and a well-watered soil are factors of extreme importance in pasture improvement especially if the materials applied are limited to lime and superphosphate. A tremendous response from these two materials cannot be expected on the lighter soil types which will not support a stand of wild white clover.

Even on the heavier soils, those which favor wild white clover as well as grasses, potash and superphosphate together appear to give a better response when used together than would be indicated where the materials are used separately.

In the Connecticut Valley area, judging by results on the Livingston farm in both pasture and hay production, potash appears to exert a more beneficial effect on clover growth than any other substance.

Farmers appear to be justified in using lime and superphosphate in making a beginning on pasture improvement on the heavier soils. After the sod is improved by these materials, then potash should be added to the fertilizer treatment for maximum results, and nitrogen as well, if there is a shortage of pasture on the farm in the spring as through the summer and fall.

Nitrogen has been consistent in producing more forage on light as well as heavy soils in the tests discussed here. While it might not prove profitable to apply nitrogen to a pasture where brush is being brought under control and where the sod is very thin, most soils will respond profitably to nitrogen when the sod is established by other means.

It should be pointed out, however, that the principal response from nitrogen applied in the spring comes soon after it is applied in spring and early summer. Many farmers need more feed all through the season and can afford to use nitrogenous fertilizers on their pastures. Others have all the feed they need in the spring and early summer, and if so, they should fertilize, if possible, to increase midsummer feed. Delayed applications of nitrogen to accomplish this end have not been thoroughly investigated but such tests are in progress. On the heavier soils, however, the use of superphosphate, potash and lime to encourage the growth of wild white clover has been found to increase midsummer forage production, since clover grows better than the grasses in hot weather.

Different nitrogen carriers have been under test for a number of years on Seavey and Livingston pastures. The carrier that has given the greatest response on Seavey gave the least on Livingston pasture, hence no definite recommendations can be made. This apparent discrepancy is doubtless due to complex soil factors. In considering nitrogen carriers, however, it should be borne in mind that sulphate of ammonia tends to make the soil more acid, whereas the other nitrogen carriers are neutral or alkaline and apparently reduce the need for separate lime applications.

A heavy triennial application of superphosphate on Seavey pasture has given better returns over a period of years than a light annual one, with equal amounts of phosphoric acid applied. With potash, the annual light treatment has been superior to a heavy triennial one.

The pastures under test yielded about 1300 pounds more dry matter per acre in the wet season of 1938 than in the dry season of 1939 with the same treatments. This suggests that moisture is an important limiting factor in pasture production and emphasizes the necessity of choosing a heavy, well watered soil for treatment.

As an average, one dollar invested in fertilizers used in these pastures has brought in about two dollars' worth of feed. Such a return appears to be ample to warrant the use of this method of improving the income on dairy farms. Kind of soil, rate of application and choice of materials are factors that will influence the economy of fertilizer usage.

The chief reason for low carrying capacity of New Hampshire pastures is lack of fertility. Restoring this fertility with fertilizer and lime will improve the feed and increase the carrying capacity of the pasture so that a farmer can confine his improvement work to a small part of his pasture acreage. Mapping out a definite fertilizer and lime schedule over a period of years will solve the pasture problem on many farms. Such a system should not involve the treatment of more than one and one-half to two acres of land for each animal unit on the farm.

Reasonable amounts of materials to apply are: one ton of lime per acre every five or eight years; 200-300 pounds of 47 per cent or 500-700 pounds of 20 per cent superphosphate every third or fourth year; 100-200 pounds of 60 per cent of muriate potash every third or fourth year or in divided applications, and 150-250 pounds of one of the nitrogen carriers annually.

If complete fertilizers are to be used, annual applications are preferable in amounts approximating 200 to 400 pounds of an 8-16-16 fertilizer, or if less nitrogen is required similar amounts of a 4-16-20 may be applied.

Farmers who do not have suitable pasture soils for improvement, or those whose acreage is limited, will need to practice other methods to get more summer roughage. Pasturing rotation fields, reseeding tillable pastures, the use of annual crops for pasture, and utilizing grasses and legumes for silage are tested methods which may be adopted as individual conditions warrant.

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