FIFTEENTH ANNUAL REPORT

of

Pasture Research

in the

Northeastern United States
State College, Pennsylvania

1951

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Fifteenth Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
State College, Pennsylvania

Division of Forage Crops and Diseases
Division of Soil Management and Irrigation Agriculture
Bureau of Plant Industry, Soils, and Agricultural Engineering
Agricultural Research Administration
U. S. Department of Agriculture
and
The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

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Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

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The Report is prepared primarily for the official use of forage crop research workers in the Region and since it is mimeographed in limited numbers, it is not available for general distribution to individuals outside the Region.

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OF

PASTURE RESEARCH

IN THE

TWELVE NORTHEASTERN STATES

FOR THE CALENDAR YEAR 1951

INTRODUCTION

Continued emphasis is being placed on implementing efficient grassland management on farms of the Northeast as evidenced by grassland field days, green pasture contests and other educational devices. The regional research program started some years ago is beginning to pay dividends not only from the standpoint of useful facts revealed, but from the standpoint of a growing consciousness of the present and potential value of grasses and legumes in the farm enterprise of the Region. In Pennsylvania alone upwards of 25,000 persons attended five grassland field days held during the late spring in various sections of the State.

The Fifteenth Annual Report of Pasture Research in the Northeastern United States follows the plan of its predecessor. Parts I, II, and III are concerned respectively with cooperative projects, Laboratory projects and state projects. A list of publications originating in the Region is appended.

Owing to a reduction of 10 per cent in the personnel budget, the Laboratory lost the valuable professional services of Dr. Helen D. Hill in December as well as the services of several part time employees for routine help. In addition D. L. Oldemeyer and W. H. Orgell resigned soon after the close of the year, the former to accept a position with the Washington Agricultural Experiment Station and the latter to continue graduate study at the University of California. After receiving a M.S. degree in Plant Pathology from Rutgers University, Victor M. Held joined the staff as part-time agent July 1.

Two changes in personnel have occurred among the Collaborators. Dr. M. A. Sprague has been appointed to replace Professor C. B. Bender who resigned from the New Jersey Agricultural Experiment Station. Dr. H. A. Keener of the New Hampshire Agricultural Experiment Station has been appointed to succeed Professor F. S. Prince who recently accepted an appointment with the United States Department of Agriculture.

The Pennsylvania State College was host to the Directors of the twelve Northeastern State Agricultural Experiment Stations and representatives of the Agricultural Research Administration for a summer conference. In preparation for this meeting and the one later in the summer by the American Society of Agronomy also held at State College, a brief history of activities at the Pasture Laboratory was prepared, mimeographed and distributed. The Forage Crops Technical Committee (NE-10) held its annual meeting in New York City and the Northeastern

Soil Research Committee met at Amherst, Massachusetts. Minutes of the meetings were prepared by the respective secretaries and distributed to interested persons in the Region.

PART I

COOPERATIVE RESEARCH

Title: PROJECT NE-10 - Adaptation, Management and Utilization of Forage Crops in the Northeast.

Leader: H. R. Albrecht, Chairman, Technical Committee

Cooperators: Connecticut, Delaware, Maine, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia Agricultural Experiment Stations and Pasture Research Laboratory.

Subproject 1 - The evaluation of forage crops, varieties, and strains for their use and adaptation in the Northeast.

Nineteen fifty-one represented the first year when all seven participating stations - Vermont, Rhode Island, New York, New Jersey, Maryland, West Virginia and Pennsylvania - made complete harvests of all grass and legume varieties and strains included in the test. During 1950 results were obtainable only at West Virginia, Maryland and Pennsylvania where tests were planted in the fall of 1949. Principal results, supplemented by projects considered contributory to the NE-10 tests are:

Bromegrass - The so-called "Southern" types, as represented by Achenbach, Fischer, and Lincoln are well adapted throughout the Region and should be recommended in preference to the "Northern" types.

Orchard grass - Yields tended to be correlated with maturity; early maturing commercial and Early Synthetic were top yielding in the Region with Late Synthetic and Finnish Late Hay uniformly least productive. Probably no named varieties can be recommended at this time because of seed shortage.

Timothy - Named varieties of timothy showed no significant differences in yield especially when yields of timothy plus associated legumes were considered. Timothy-red clover associations appeared to be more productive than timothy-Ladino clover.

Birdsfoot trefoil - Viking and Italian, both upright in habit of growth regularly outyielded Empire, a prostrate variety that may show greater persistence under grazing. Italian proved to be amply hardy to withstand weather conditions as they occurred in the Region during 1951. Yields were greatest when birdsfoot trefoil was planted alone followed by its association with timothy, bromegrass and orchard grass in that order.

Ladino clover - A considerable degree of variation in production and adaptation was obtained in Ladino clover lots tested, even among the certified sources. California Improved yielded disappointingly in the test. Ladino clover plus bromegrass proved the most productive association generally, with Ladino-timothy combinations as good or better at the more Northerly Stations. Ladino-orchard grass was most productive at West Virginia. Type of management appeared to have no important influence on Ladino clover production.

Alfalfa - Narragansett and Northern Synthetic proved outstanding in Pennsylvania and further north, whereas Atlantic led in production at New Jersey and Williamsburg appeared well adapted at Maryland and West Virginia. Wilt resistant varieties that can be recommended in the Region include Ranger for the north and Buffalo in the Southern areas.

Red clover - Kenland and Pennscott were outstanding in all tests, the former most conspicuously at the more southerly stations and the latter from Pennsylvania north.

A second objective of Project NE-10 is the multiplication of promising strains of forage crops developed in the Northeast and elsewhere to permit their testing under a variety of conditions in the Region. Towards this end, New York has undertaken the multiplication of bromegrass and birdsfoot trefoil strains; Pennsylvania, orchard grass and alfalfa (at Nebraska, by contract); Maryland, Ladino clover; New Jersey, red clover.

Although multiplications must still be furthered, tests of advanced lines of bromegrass, orchard grass and alfalfa have already been established in the Region.

BROMUS INERMIS BREEDING

Leaders: For the Pennsylvania Agricultural Experiment Station - H. R. Fortmann and H. L. Carnahan
For the Pasture Research Laboratory - J. H. Graham

Clonal evaluation: The material referred to in last year's report was evaluated again in 1951 and the data for 1950 and 1951 is being summarized for analysis. Two or three synthetics can be made up on the basis of results from these tests. See NE-10 report for further aspects.

Source material: Data were taken in 1951 on the spaced-plant nursery established in 1949 and selections will be made on the basis of the 2 years notes.

Polycross Nursery: Seed was harvested from the 67 clones established in 1950.

Varietal testing: Yields were taken again in 1951 on the regional bromegrass varietal tests and the Southern strains continue to prove their superiority over the Northern strains at State College, Wernersville, and Harvey's Lake. At the two sites in the Western part of the state, Blairsville and Meadeville, the intermediate to Northern types such as Manchar were superior to the southern types in 1951. This was particularly evident for the second cutting.

DACTYLIS GLOMERATA BREEDING

Title: Selection, Inbreeding, and Crossing to Obtain Orchard Grass Strains Adapted Particularly for Pastures.

Leaders: For the Maryland Agricultural Experiment Station - T. S. Ronningen and A. W. Burger
For the Pennsylvania Agricultural Experiment Station - H. L. Carnahan and H. R. Fortmann

For the Division of Forage Crops and Diseases - R. A. Wagner
For the Pasture Research Laboratory - A. A. Hanson

At Beltsville, Maryland

Nursery of Spaced Plants: The present nursery consists of 72 selections taken from old polycross nurseries, plus 6 additional selections from a miscellaneous nursery. Three replications of five plants each of these clones were established. This material is being further observed and selected pending results of their progeny tests. At the appropriate time certain of these clones will be put together as synthetic strains.

Again in 1951 rust was serious on orchard grass, particularly in the fall. This is the second year in a row that it has been possible to rate rather critically the various clones as to their resistance to rust. Striking differences were observed. Some plants, including XXXIV-18, XXXIV-27, and XXXVI-15, were practically free of rust, while others were severely infected. Among the latter group were XXXIII-10, XXXV-30, and XII-2. As a matter of fact the incidence of rust together with dry weather at critical times completely eliminated some of these plants. It is encouraging to know that there is clear-cut resistance to rust in the orchard grass breeding material.

Progeny Tests: A progeny test of the plants selected in 1948 from the polycross nurseries was seeded in the spring of 1949. Plots of other strains were also seeded to study their performance and to compare them with the polycross seedings. These include the Beltsville strain, an introduction that has been increased in Arizona, a Kentucky strain, a late maturing strain from Massachusetts (Finnish Late Hay), Wisconsin 52, Pasture Laboratory Synthetics Plots 1, 3 and 5, S-37, S-143, Tammisto, two seed sources of Brage, and a commercial source.

These plots were seeded in a split plot design of four replications with maturity groups as the main plots. Each of the four maturity groups is composed of 17 strains. Strains and progenies of maturity Group I were seeded in pure stand as well as with Ladino clover, while those of Groups II, III, and IV were seeded with Ladino clover only. Commercial nitrogen is applied to the pure seedings.

Dry matter yields were obtained from four harvests in 1951. Yields of the mixture of grass and legume were determined for each strain and progeny, as well as the grass component based on estimated percentage composition of the mixture. In Group I yields of the grasses in pure stand were also obtained. Selections differed somewhat more when yields were based on the grasses in pure stand or on the grass component only of the mixture rather than on the total mixture. Ladino clover in the mixtures compensated for the lack of grass in many instances, thereby leveling out differences in yields. It was therefore more difficult to pick up differences in yield among the selections in the mixed stands. Although statistical analyses have not yet been completed on these data, there appears to be some correlation between yields of the grass component only and those of the total mixture; but there are some notable exceptions. The same is true where comparisons can be

made between the grasses in pure stands and in mixture with Ladino clover. Generally, selections in Group I and Group II were more productive than those in Group III and Group IV.

Within Group I, Arizona was least productive of all selections. S-143 and Commercial were also near the bottom, although the small difference in yield between Commercial and many of the others above it will undoubtedly not be statistically significant. Most productive of this group were AI-4 and AI-12. Beltsville was near the top in pure stands but intermediate when grown in mixture. XXXIII-40 was near the top when yields were figured on the pure stand or on the grass component of the mixture, but it ranked number 16 out of the 17 when yields of the total mixture were the criterion.

Within Group II, highest yielders were XXXIV-27, XXXIV-31, XXXIII-8, and XXXIV-18. Lowest yielder of the group was S-143, and Syn. 3 was very little better. Commercial was intermediate.

Outstanding in yield among selections in Group III were XXXV-5, XXXV-32, and XXXVI-25. Tammisto, Finnish Late Hay, and S-143 were the lowest yielders of the group. Commercial ranked second in yield of the grass component only, but eleventh in yield of the mixture.

Most productive in Group IV were XXXVIII-23, XXXVII-18, and XXXVII-4. Lowest of the group were S-37 and S-143. Commercial ranked second in yield of the grass component only, but sixteenth when yields were based on the total mixture.

Beltsville was superior to all other strains in late summer and fall growth during 1951, as measured by the accumulative growth from July 31 to October 15. It made a greater proportion of its total growth in late summer and fall than some of the other higher producing strains such as AI-4 and AI-12. Fall growth of S-143 was also good but it did not measure up to Beltsville in this respect. Tammisto and Finnish Late Hay were low in late summer and fall production.

Since no cuttings were made between July 31 and October 15, rust developed rather heavily on the susceptible material. Beltsville and 32-16 were especially outstanding in resistance to rust. S-143, AI-12, and AI-19 also showed considerable resistance.

Selections other than those already mentioned that have shown some promise at one time or another during the season include: XXXIII-5, XXXI-3, XXXI-5, XXXI-9, and XXXV-5.

At College Park, Maryland

Clonal evaluation: Further observations were made on the 218 clones in the polycross nursery established in 1949. This nursery will be maintained pending results of polycross progeny tests.

At State College, Pennsylvania (Experiment Station)

Clonal evaluation: Data were obtained again in 1951 on the material described on Page 7 of the 1950 report. When this is summarized it will be possible to make some synthetics which should give yields superior to the present Pasture Laboratory synthetics. See NE-10 report for description of other work.

Source material: Data were taken on the spaced polycross progeny mentioned under 1-b of the 1949 report and approximately 185 plants have been selected for inclusion in a 1952 polycross nursery. Open pollinated seed was harvested from most of these selections and will be held in reserve to plant in comparison with polycross seed.

Orchard grass introduction: Open pollinated seed was harvested from P.I. 173695 and P.I. 175131.

Varietal testing: The performance of earlier varieties was superior to that of later varieties as was true in 1950, except where the later strains were harvested about three weeks later than the early varieties. When handled in this manner, the yield of the later strains was comparable to that of the early strains.

At State College, Pennsylvania (Pasture Research Laboratory)

Existing plantings were studied intensively in the summer of 1951 in an effort to isolate plants with some degree of resistance to the common leaf spots. Twenty-nine plants were selected for resistance to one or more of the following diseases: Stagonospora leaf spot, leaf streak, Anthracnose and rust. In addition, twenty plants were selected on the basis of maturity and aftermath production, from progenies representing crosses between late and early types (1949 Annual Report, page 42).

PHALARIS ARUNDINACEA BREEDING

Leaders: For the Pennsylvania Agricultural Experiment Station - H. R. Fortmann and H. L. Carnahan
For the Pasture Laboratory - J. H. Graham

Clonal evaluation:
a. The 1950 seeded plots of polycross progenies of 46 clones were clipped in 1951 to allow further establishment.
b. The space planted polycross progeny and parent clones were harvested and notes taken on this material which also serves as a source nursery.

Polycross nursery:
Seed was harvested from the 95 clones established in 1950.

Varietal testing:
Williams Bros. source from Wisconsin continued to look good.

PHLEUM PRATENSE BREEDING

Title: The Improvement of Timothy by Selection and Breeding

Leaders: For the New Hampshire Agricultural Experiment Station - F. S. Prince, S. J. Higgins, P. T. Blood and G. M. Dunn
For the Pennsylvania Agricultural Experiment Station - H. L. Carnahan and H. R. Fortmann
For the Pasture Research Laboratory - J. H. Graham

At Durham, New Hampshire

Polycross seed of 23 timothy clones of a late hay strain and 12

clones of a pasture strain were produced during the year. These will be planted in replicated plots in 1952 for further evaluation.

At State College, Pennsylvania (Experiment Station)

Clonal evaluation: Spaced plants of polycrosses of 56 New York clones were harvested and observed. Another year's data will be taken on this material.

Source material: The material described on Page 9 of the 1950 report was harvested and other notes were taken. This material will be studied another year before making selections.

Polycross nursery: Seed was harvested from the 56 clones established in 1950.

Varietal testing: The earlier varieties, Itasca, Milton, and Medon, yielded more than the later varieties.

LOTUS CORNICULATUS BREEDING

Leaders: For the Pennsylvania Agricultural Experiment Station -
H. L. Carnahan and H. R. Fortmann
For the Pasture Research Laboratory - J. H. Graham

Source material: The source nursery established in 1948 was maintained and inoculated with Rhizoctonia early in September. The usual conditions, favorable for the development of the disease, did not result and infection was not complete enough to aid selection for resistance. Another attempt at inoculation with Rhizoctonia will be made in 1952.

Polycross nurseries: Seed was harvested from the 35 clones selected from Empire and the 79 clones selected from European sources. Enough seed was harvested from most of the clones for adequate progeny testing.

Varietal testing: The 10 strains listed in the 1950 report were harvested again and the differences between varieties were greater than in the first year. Bunker, a narrow leaf variety which was tops in 1951, yielded poorly. This is in agreement with results with this variety in New York. A new uniform variety test with 10 entries was seeded in four replications at State College.

MEDICAGO SATIVA BREEDING

Title: Breeding Improved Alfalfa for the Eastern United States

Leaders: For the New Jersey Agricultural Experiment Station -
Warren R. Battle and G. H. Ahlgren
For the Cornell University Agricultural Experiment Station -
(See Part III for project leaders and report)
For the Pennsylvania Agricultural Experiment Station -
H. R. Albrecht, H. R. Fortmann, and H. L. Carnahan
For the Rhode Island Agricultural Experiment Station -
T. E. Odland
For the Division of Forage Crops and Diseases - O. S. Aamodt

For the Pasture Research Laboratory - A. A. Hanson and J. H. Graham

At New Brunswick, New Jersey

1948 Advanced Uniform Nursery: Yields during the fourth season showed that polycross progenies of C53, C22, C230 and the Atlantic variety were best of the 21 strains and varieties in this test. Synthetic A225, Ranger, Ladak and Grimm were lowest yielding. Results of this test are reported in detail in the 1951 Report of the Uniform Alfalfa Nurseries.

1950 Wilt Nursery: Survivors of the 10,000 wilt inoculated spaced plants from Atlantic parental strains were rated for agronomic characters. A number of plants were still showing varying degrees of wilt infection. The nursery was held over for another season, after which seed will be obtained from the best of the surviving plants.

1950 Plant Introduction Nursery: 75 plant introductions of alfalfa from India, Turkey, Syria and Saudi Arabia were grown in duplicated six-foot rows. Notes were obtained on a number of plant characters and are reported in detail in the 1951 Report of the Uniform Alfalfa Nurseries. Several Turkish and Syrian lines appear promising and are worthy of further testing. The heavily pubescent Saudi Arabian lines which were observed to escape leaf hopper injury in 1950 proved to be non-hardy and were killed by the first cold weather.

1951 Wilt Nursery: Progenies of 149 selections from Atlantic parental strains were inoculated with the bacterial wilt organism in a second-cycle elimination of susceptible types. These progenies had previously been rated for establishment and early vigor in replicated broadcast plots, after which 100 of the best plants from each progeny were dug up, inoculated with the wilt organism and transferred to a spaced nursery of 1500 entries.

1951 Northeast Uniform Alfalfa Nursery: 74 of the better clones from the National Alfalfa Improvement Conference testing program, plus two experimental lots and 6 check varieties were seeded in a replicated test. Dry weather this fall delayed emergence so that the material went into winter with little growth. As a result there may be considerable winter-killing in this test.

Seedling vigor study: Data obtained during the past three seasons indicates that selection of alfalfa plants on the basis of seedling vigor is an effective means of securing high yielding plant populations. Selfed and outcrossed seed obtained from the plants in this study during the past season is being used to determine the extent to which the yield advantage is transmitted to the progeny.

Increase of Atlantic Alfalfa: A new five acre seed field for the production of breeders seed of Atlantic alfalfa was established. Seedlings were transplanted to spaced rows with the aid of a lettuce transplanter. The entire area was later overseeded with timothy in order to retard the growth of weeds and volunteer plants. First seed harvest from this field will be obtained in 1952.

At State College, Pennsylvania (Experiment Station)

Data have been obtained on the nurseries listed in the 1950 report and forwarded for inclusion in the 1951 report of the Alfalfa Improvement Conference.

One additional advanced uniform nursery of 49 entries was established at State College. Varietal tests with 10 entries were seeded at six locations in the state.

Source material: Approximately 1000 F_1 plants of crosses between DuPuits and wilt resistant clones were established.

At State College, Pennsylvania (Pasture Research Laboratory)

A space planted progeny test of 121 entries was planted in four replications of ten plants each in the spring of 1951. This nursery included progenies from 49 C clones and 50 new selections made at New York and New Jersey. Seed of these entries was produced in Nebraska under the auspices of the N.E. Forage Crops Technical Committee.

Due to unfavorable weather conditions no seed was obtained from the 28 new selections and the two restricted polycrosses planted in Nebraska (1950 Annual Report, page 12.).

A clonal planting of 80 new selections was planted in the spring of 1951. These clones were also brought into the greenhouse in the fall of 1951 for crossing and selfing. A large proportion of these plants exhibit various degrees of the rhizomatous habit.

At Kingston, Rhode Island

Alfalfa breeding and strain testing was interrupted at this station during the year when all existing synthetic and advanced nurseries had to be discontinued because of their proximity to the Narragansett alfalfa breeder seed fields. Some seed was obtained from three synthetic nurseries but no data was obtained from the advanced nurseries before they were plowed.

The main objective of the breeding work has been to incorporate some wilt resistance into the Narragansett type alfalfa. Resistance to leaf spot and black stem has also been considered as well as seed producing ability.

Seed collected in 1950 and 1951 from five synthetic nurseries has been sent to Nebraska for wilt testing. No information has been obtained on the tests at this time.

An advanced nursery was seeded in August of this year and plans for continuing the breeding work are being formulated.

TRIFOLIUM PRATENSE BREEDING

Title: The Improvement of Red Clover by Selection and Breeding

Leaders: For the New Hampshire Agricultural Experiment Station - F. S. Prince, L. J. Higgins, P. T. Blood and G. M. Dunn

For the Pennsylvania Agricultural Experiment Station -
H. L. Carnahan and H. R. Fortnamn and R. G. Hanson
For the Pasture Research Laboratory - J. H. Graham

At Durham, New Hampshire

Hand pollination has been continued in the greenhouse and plants have been selected for vigor and freedom from disease. Breeder's seed obtained in this manner during the past year has been planted in the field and a good stand has been obtained. Seed will be available for yield trials in comparison with other varieties this year if testing seems desirable. During the past year, seed from field multiplication was sent to Dr. E. A. Hollowell, U.S.D.A. for trial distribution.

At State College, Pennsylvania (Experiment Station)

Source material: A second cycle source nursery consisting of 4400 open pollinated progeny of plants selected from the 1949 source nursery was established in four replications with ten plants per row. This planting was delayed until July 20 in order to limit the growth of these spaced plants to something comparable to the growth of plants in a normal seeding. The dry summer resulted in a considerable loss of plants.

In addition, plants from 8 single crosses and one polycross of Sclerotinia "resistant" clones were established. Seven single crosses and six polycrosses of Fusarium "resistant" clones were also established.

Varietal testing: The tests seeded in 1949 were observed in 1951 and the stands of all varieties had almost disappeared at 4 of the 5 locations. At Wernersville, however, there were sufficient plants of Pennscott and Kenland to warrant harvesting. Pennscott gave a yield of 1.68 tons of D.M./acre as compared to 1.28 for Kenland in the second crop year.

In the test seeded in 1950 in which Sclerotinia inoculum was applied to two replications, two replications were sprayed with Systox and two replications were left untreated, there was no significant effect from these treatments. Pennscott and two Lancaster county strains were the top yielding varieties of the 12 tested.

New seedings of eight varieties were made at five locations in the state. Twelve additional strains were included in the test at State College.

At State College, Pennsylvania (Pasture Research Laboratory)

Resistance of Red Clover to Sclerotinia trifoliorum

The results of the field and greenhouse inoculation tests of 1950-51 (1950 Annual Report, pages 14-15) gave highly significant differences between strains. Strains which originated in areas where Sclerotinia

crown rot is a problem were most resistant. Highest resistance was shown by Offer, Ultuna and Svalof strains from Sweden and Tamisto from Finland. Kenland, Midland, and Cumberland strains from Central United States also were among the more resistant material tested in the field and in the greenhouse. Results indicate that resistance is heritable. A highly significant correlation (+.57) was obtained between greenhouse and field inoculations.

In a field experiment on the rate of application of grain inoculum (Annual Report, 1950, page 15), good infection was obtained by scattering the inoculum over the plots at the rate of 5-10 cc. per square foot. Observations indicate that the best time to apply inoculum was in the late fall during cool, damp weather. Polycrossed seed from progenies of single crosses and polycrosses which survived one or more inoculations have been harvested for further study.

Resistance of Red Clover to Fusarium sp.

Greenhouse studies with the dried grain inoculum was continued during 1951 (see Annual Report 1950, page 15). F_1 and polycrossed progenies from parents which survived one or more inoculations were tested. The survivors were polycrossed in the Spring of 1951 (in greenhouse using bees). This resulting seed will be tested further in the greenhouse and field.

TRIFOLIUM REPENS BREEDING

Title: The Improvement of Ladino clover by Selection and Breeding

Leaders: For the New Hampshire Agricultural Station - F. S. Prince, L. J. Higgins, P. T. Blood and G. M. Dunn
For the New Jersey Agricultural Experiment Station - G. H. Ahlgren
For the Pennsylvania Agricultural Experiment Station - H. R. Albrecht and W. E. Knight
For the Pasture Research Laboratory - A. A. Hanson

At Durham, New Hampshire

Further intercrossing was done during the year among promising families. Selections among those already at hand were made, but cloudy and rainy weather prevented the production of polycross seed. This will be attempted again in 1952.

At New Brunswick, New Jersey

Progeny Tests of Diallel Crossing System.

Seed Production: This phase of project has been temporarily discontinued since enough seed is on hand for preliminary field tests of three strains.

Field Plot Tests: The strains known as 6-10 x 6-13, 6-5 x 6-16, and a close-pollinated strain are in their second year of comparison with Ladino strains from Oregon, Idaho, Montana, California and Italy. Results for the past year have not been analyzed but no major differences among those strains have been noted.

A second planting, now in its third year, compared 6-10 x 6-13 with

18 other strains from the United States and Europe. As in previous years this cross has been as productive as other strains, possessed good winter and summer survival, and has looked good in resistance to leafhopper. It is somewhat shorter and has a more dense growth habit than other Ladino clovers.

At State College, Pennsylvania (Pasture Research Laboratory)

A total of 50 clones which had been rated on the basis of persistency were planted in a polycross nursery in the spring of 1951. This planting includes 15 clones from the Sclerotinia testing program, 12 clones from the 1947 polycross nursery (1948 Annual Report, page 14) and 23 clones from the 1948 polycross nursery (1950 Annual Report, page 17). Several intermediate types, e.g. 1947 No. 44, were brought into the greenhouse for crossing with larger types. Selection in these progenies will be for ability to produce numerous stolons while retaining leaf and petiole size.

A space planted observation nursery of 19 sources was planted in 5 replications of 20 plants each. There were 8 certified and non-certified lots produced in the western states and 7 lots representing different districts in Italy. The planting also includes two lots of Breeder's seed, Iowa Recombination (F.C. 24,051) and a sample of white clover from Costa Rica.

The field persistency ratings of single cross progenies from good x good, good x poor and poor x poor crosses (parents ranked on the basis of persistency) were similar to those obtained in 1950 (1950 Annual Report, page 17). In general, crosses involving persistent clones were far superior to those involving poor clones. Artificial inoculation tests indicated that the parental clones did not differ in their reaction to Sclerotinia.

Some of the characters which were significantly correlated with persistency are as follows: Total number of stolons (+.74), stolon diameter score (-.52), vigor in greenhouse after flowering (+.40), and lateness of flowering (+.32). No association was found between rooting ability of stolons in the greenhouse and winter survival. Rate of growth was measured at the same time and its association with winter survival was negligible.

NUTRITION STUDIES

Title: The chemical composition of the pasture grasses

Leaders: For the New Hampshire Experiment Station - T. G. Phillips
For the Pasture Research Laboratory - J. T. Sullivan

Studies have been continued on grasses growing in small plots at State College, Pennsylvania. Chemical analyses are being made partly at the New Hampshire Station and partly at the Pasture Research Laboratory (1950 Annual Report, page 18).

Results obtained from samples taken in 1948 and 1949 from the grasses at different stages of maturity are being prepared for publication. Statistical analyses of the data were made to determine:
(1) Changes in composition of a species between successive stages of maturity;

14.

(2) Differences in composition between the two successive years;
(3) Relative standing of species in respect to a constituent; and
(4) Correlations among constituents.

Some typical and significant results are: (1) Significance of changes in composition between two successive stages of growth was usually high, especially between Stage I and Stage II (1949 Annual Report, page 25). Significance was usually lacking between Stage V and Stage VI. (2) Agreement between the two years, 1948 and 1949, was close. The closest agreement was in the lignin content and there was moderately close agreement in protein. (3) Reed canary tended to be the species highest in protein and soluble ash and lowest in lignin while timothy tended to the other extreme in these respects. Both reed canary and Kentucky bluegrass were significantly higher in protein than tall oat, orchard grass, red top and timothy in 1949. Timothy was lower in protein than orchard grass and tall oat in 1948 and lower than reed canary, Kentucky bluegrass, bromegrass and alta fescue in both years. (4) Some significant correlation coefficients were:

Between protein and lignin, for all species in 1949, $r = -0.914$,
Between protein and crude fiber, for all species for both years $r = -0.781$,
Between lignin and cellulose, for orchard grass in 1948, $r = +0.983$,
Between lignin and cellulose, for all species in 1948, $r = +0.891$,
Between lignin and crude fiber, for all species for both years, $r = +0.894$,
Between lignin and fructosan, for reed canary in 1949, $r = +0.715$

Samples taken during 1950 from successive cuttings throughout the growing season (1950 Annual Report, page 18) have been analyzed for protein, total and soluble ash, cellulose, and lignin. Statistical analyses were made for differences among the successive cuttings of the same species, for differences among species, and for correlations among the different constituents. The most important factor affecting the protein content of the different cuttings of the same species was the time elapsed since the last application of fertilizer; protein was highest in cuttings made about two weeks after fertilization. Reed canary and Kentucky bluegrass were significantly higher than other grasses in protein at most dates and reed canary and tall oat grass were low in lignin. Significant negative correlations were obtained between protein and lignin and between protein and cellulose and positive correlations between lignin and cellulose for all cuttings, but significance was not always obtained within a single species.

Title: Measurement of the Nutritive Value of Pastures and Pasture Plants

Leaders: For the Pennsylvania Agricultural Experiment Station - R. W. Swift and J. B. Washko
For the Pasture Research Laboratory - J. T. Sullivan and V. G. Sprague

Previously reported work (1949 Annual Report, page 26) involving the nutritive value of specific forages, as determined by digestion and calorimetric experiments with sheep, has been extended to include Ladino clover and to repeat the tests made with Kentucky bluegrass.

The top position of Kentucky bluegrass as given in the 1949 report was verified. It is now possible using previous data and that reported below (See Table I) to express the metabolizable energy, per kilogram of dry matter, as follows:

Kentucky bluegrass	2647 cal.
Orchard grass	2537 cal.
Ladino clover	2528 cal.
Bromegrass	2516 cal.
Alfalfa	2290 cal.
Timothy	2162 cal.

During 1950 (1950 Annual Report, page 19) successive cuttings of orchard grass and bromegrass were taken during the growing season. In each the first cutting was taken when the heads had just emerged from the boot, but before they had expanded. In all, six cuttings of orchard grass were obtained, from May 15 to October 10, the last cutting having been subjected to two severe frosts. The results are given in Table 1. It was found that the protein content of the orchard grass as well as the digestibility of most of the feed constituents decreased as the season progressed. An application of ammonium sulfate (40 pounds per acre) after the third cutting of orchard grass resulted in the fourth cutting in an increase in protein and an increase in the digestibility of all feed constituents except ether extract. The trend toward lower nutritive values with advance of the season is evident from the lowering energy values and total digestible nutrients. There is no evidence that frost decreased the nutritive value of the last cutting. Due to limited growth and disease only two cuttings of bromegrass were obtained and the second was of lower nutritive value than the first.

A study was made of the effect of stage of maturity at the time of harvest on the nutritive value of timothy hay. The first cut when the head had emerged from the boot but not flowered was "too early". The "on time" cutting was made from a separate plot during the early bloom stage and the "too late" from another plot when just past full bloom. The dates were June 6, 20, and 30 respectively. There were marked differences among the different cuts in protein, crude fiber, and nitrogen-free extract, the last two constituents increasing with the progress of maturity. There were decreases in the digestibility of these constituents and in the nutritive value of the forage with advancing maturity whether measured by the metabolizable energy, digestible energy, digestible dry matter, or the total digestible nutrients. A concomitant measure of the amount per acre of timothy reveals that the increase in yield of the "on time" cutting more than makes up for the decrease in protein content and digestibility. However, the nutritive value per acre of the "too late" cutting is about 15 per cent less than that of the "on time" harvest.

These results are being prepared for publication.

Additional analyses were made on those forages previously reported (1949 Annual Report, page 26), for lignin, alpha-cellulose, and natural cellulose. The results are given as averages in Table 2. In those grasses cut at the same stage of growth, namely when the head was half emerged from the boot, the highest lignin and cellulose contents were found in timothy and the lowest in bluegrass. Natural cellulose was higher than alpha-cellulose by 7-9 per cent of the dry weight in the grasses, but only 1.5 per cent higher in alfalfa,

an indication that the cellulose of alfalfa is different than that of the grasses. The coefficients of digestibility of the celluloses were inversely correlated with the lignin content, not only among species, but also among plot replications in the same species. The coefficients of digestibility of natural cellulose were slightly but consistently lower than those of alpha cellulose. An unexpected result was the high lignin content of the alfalfa and the low coefficients of digestibility of its celluloses.

Table 1. Composition, digestibility and energy values of forages harvested in 1950.

Species	Cut	Protein %	Crude Fiber %	Total Energy Cal. per Kg.	Metabolizable Energy Cal./Kg.	Digestible Energy Cal./Kg.	Total Digestible Nutrients Kg./Kg.
Orchard gr.	1	25.8	20.8	4,695		3,570	.768
"	2	18.9	27.2	4,522		3,266	.728
"	3	13.1	29.6	4,427		2,780	.637
"	4	21.0	28.2	4,694		3,132	.678
"	5	13.2	28.2	4,538		2,678	.619
"	6	13.7	26.8	4,485	2,128	2,684	.617
Brome	1	24.0	21.3	4,640		3,513	.776
"	2	18.3	26.7	4,509		3,221	.717
Timothy hay	1	24.8	31.8	4,519	2,412	2,926	.669
"	2	8.4	36.3	4,563	2,120	2,556	.585
"	3	6.4	38.2	4,530	1,716	2,144	.499
Kentucky bluegrass	*	17.9	26.5	4,596	2,594	3,190	.713
Ladino clover	**	22.9	18.9	4,372	2.528	3,179	.705

* 1948 bluegrass
** Clover from plots at Harvey's Lake, Pa.

Table 2. Lignin and cellulose contents and the coefficients of digestibility of cellulose in forages harvested in 1948.

Species	Description	No. of Plots	Lignin %	Alpha Cellulose %	Alpha Cellulose Coeff. Digest.	Natural cellulose %	Natural cellulose Coeff. Digest.
Timothy	Half emerged	5	8.3	33.3	67	42.4	65
Brome	Half emerged	6	6.1	32.4	78	40.2	77
Orchard	Half emerged	6	6.0	30.0	80	38.8	79
K. blue	Half emerged	1	4.7	25.9	86	32.7	83
K. blue	2nd cut	3	6.2	28.3	78	37.9	75
Orchard	3rd cut	2	6.0	27.9	79	35.2	78
Orchard	1st cut, 1949	1	5.7	27.9	79	34.9	77
Alfalfa	2nd cut	1	9.2	24.6	64	26.1	61

Title: Effect of Height and Frequency of Cutting on the Carbohydrate Reserve of Ladino Clover

Leaders: For the Maine Agricultural Experiment Station - C. H. Moran
For the Pasture Research Laboratory - V. G. Sprague

A study of the changes in the carbohydrate content of the stolons and roots of Ladino clover has shown that starch, sucrose and reducing sugars are stored in these organs. The stolons, however, contain approximately 50 per cent more total carbohydrates than do the roots. These carbohydrates are utilized by the plant during the development of new growth. Depletion of carbohydrates continues for 9-12 days after cutting and then a gradual accumulation follows. When plants are cut at 1 inch above the soil level, approximately 28 days are required before the concentrations reach the initial levels. At 3-inch height of cutting, the initial concentrations were reached in approximately 21 days.

Further greenhouse and field studies are being made to determine the relationships of associated species, time and amount of fertilizer applications to the rapidity of storage of carbohydrates following defoliation.

Title: Evaluation of Grasses and Legumes for Hay, Silage and Pasture

Leaders: For the Pennsylvania State College - P. H. Margolf, M. G. McCartney, J. B. Washko, R. P. Pennington and A. L. Haskins
For the Pasture Research Laboratory - V. G. Sprague

Experiment I: Evaluation of an orchard grass-Ladino clover association for turkey pastures under two systems of grazing management differing in intensity

Pasturing of these areas began May 18 for the seventh successive year. The populations of the 2 acre areas were 150 and 300 poults respectively as in the preceding years. Both areas were grazed rotationally, about three weeks being required for a rotation. All equipment, shelters, feeders and waterers were moved daily. The poults were fed in outdoor hoppers a 20 per cent protein turkey growing mash mixture, whole oats, whole wheat, whole corn, oyster shell and grit.

Results of seven years is given in the following table.

Table 3. The pounds of turkey produced per acre, pounds of feed to produce a pound of gain, and mortality expressed in per cent, for each year under two intensities of grazing.

	1945	1946	1947	1948	1949	1950	1951
Pounds of turkey produced per acre							
Light grazing	531	709	786	936	1106	952	986
Heavy grazing	911	1231	1702	1887	2198	1869	1893
Pounds of feed to produce one pound of gain							
Light grazing	5.0	6.7	7.0	5.3	6.0	5.9	5.2
Heavy grazing	5.1	6.7	6.5	5.4	5.6	5.9	5.2

	1945	1946	1947	1948	1949	1950	1951
Mortality per cent							
Light grazing	9.8	1.5	8.2	7.7	11.8	3.3	3.9
Heavy grazing	8.3	7.2	7.4	6.5	11.6	4.0	3.7

Intensity of grazing influences both forage yields and protein content of orchard grass. Under light grazing (75 poults per acre) the orchard grass yielded 2796 pounds of dry matter per acre for the season as compared with 3846 pounds per acre when heavily grazed (150 poults per acre). The protein content of the forage sampled monthly throughout the season was about 20 and 22 per cent on the light and heavily grazed areas respectively.

Experiment III: Carrying capacity of individual species of grasses and legumes for turkeys on pasture and the growth responses of the turkeys where supplementary feed of different protein levels is supplied.

Grazing trials with turkey poults were continued in 1951 on the one-acre ranges. Fifteen hundred White Holland Turkey poults were brooded and fed the Pennsylvania State College starter mash (25 per cent protein) until they were 8 weeks of age. Then they were given the 20 per cent protein developer mash until they were 9 weeks and 2 days old. At which time they were taken at random from the brooding pens and divided into thirteen groups consisting of 120 poults each and moved to range.

Four groups placed on orchard grass were fed mash mixtures of 20, 17, 14 and 11 per cent protein content respectively. Other groups were reared on Kentucky bluegrass, smooth brome, and reed canary grasses, and mash mixtures were used of 17, 14, and 11 per cent protein respectively on replicated areas of the grass species.

Body weights taken at 3 week intervals from all specimens indicated that the birds on the higher proteins were putting on the most rapid gains to 21 weeks of age, after that the body gains were the same from lowest to highest protein levels fed.

The total amount of forage available for turkey grazing expressed in terms of dry matter per acre for the season for each species was as follows: orchard grass 2597 pounds, Kentucky bluegrass 2072 pounds, reed canary grass 1898 pounds, and bromegrass 1594 pounds. These yields were lower than those obtained in 1950 due to a severe late summer and fall drought. The average per cent protein content of these various species for the season was as follows: orchard grass 18.9, Kentucky bluegrass 19.0, reed canary 21.0 and brome 20.2. The orchard grass and Kentucky bluegrass had the highest carrying capacity, with reed canary/and bromegrass the lowest for the season.

PASTURE RENOVATION EXPERIMENTS

Title: Grassland renovation trials in Connecticut

Leaders: For Storrs Agricultural Experiment Station - B. A. Brown and R. A. Peters
For the Pasture Research Laboratory - V. G. Sprague

At Storrs Connecticut

Two-acre grazed plots.

Plot 4N was disked during the fall of 1948, seeded with Ladino in March 1949, disked and seeded again in August 1949, and disked and seeded a third time in July 1950. A fourth seeding was made in March 1951. Since 1947, the plot received 46% superphosphate at 400 pounds, 60% muriate of potash at 600 pounds, and limestone at one ton. Before 1947, it had been limed and fertilized several times. Although little Ladino had become established by the early fall of 1950, the plot had about a 50 per cent stand in May 1951 and in consequence produced nearly as much pasturage that season as the best plots in the series, including two which received fertilizer nitrogen in addition to minerals.

In an attempt to determine the reasons for the poor results from seeding Ladino on disked land (4N), soil from a similarly fertilized but undisked plot was collected by 0-2, 2-4 and 4-6 inch layers, treated with various combinations of L, P and K and planted to Ladino in the greenhouse. Marked differences were found in the growth of Ladino on the various layers of soil. Without any direct treatment, the Ladino produced respectively three and eight times as much on the 0-2" as on the 2-4" and 4-6" soils. Even with direct LPK fertilization, the 0-2" soil was much more productive than the lower layers. Probably these differences were due to the accumulation of P in the 0-2" layer from the several surface applications of superphosphate since 1927. It is apparent that these greenhouse tests do not explain the failure to establish Ladino on the disked pastures.

In a large scale attempt to establish Ladino on an untilled pasture by first killing the existing vegetation with a herbicide and then seeding the clover on the frost cracked ground in early spring, "Atlacide" was spread on the two-acre permanent pasture plot 4S at 100 pounds in the fall of 1948 and at 200 pounds in July, 1950. This plot was fertilized about the same as 4N. Little of the Kentucky blue, Rhode Island bent or red fescue grasses was killed by either of the herbicidal treatments and scarcely any Ladino was established from seedings in March 1949 and March 1951. For some undetermined reasons, Atlacide has been a much less effective grass killer on this permanent pasture than on nearby land which, though long untilled, has been harvested more times by mowing than by grazing.

A new series of small plots was treated on December 11, 1951 with five herbicides, each at three levels. The plots were 7 by 20 feet, replicated three times with a randomized block design. The treatments were as follows:

1) Sodium chlorate - 100, 200 and 400 pounds per acre
2) Ammonium thiocyanate - 100, 200 and 400 pounds per acre
3) Calcium trichloroacetate - 50, 100 and 200 pounds per acre
4) Chlorophenyl dimethyl urea (CMU) - 50, 100 and 200 pounds per acre
5) Chloro isopropyl phenyl carbamate (Cl IPC) - 50, 100 and 200 pounds per acre.

Still another of the two-acre pasture plots has been renovated by disking and seeding Japanese millet in early July 1950, and re-disking and planting rye in September 1950. In March 1951, Ladino was sown in the rye. The rye was grazed in May and June and produced 1150 pounds (72 cow days) per acre of digestible nutrients. The interseeded Ladino provided 275 pounds (17 cow days) of digestible nutrients in August. These yields made this one of the most productive plots last year, but the cost per unit was much higher than on the non-renovated pastures. Several years of good Ladino pasture will be required to justify such methods of improvement.

Title: Date of seeding legumes, grasses and weeds

Leaders: For the Vermont Agricultural Experiment Station - A. R. Midgley
For the Pasture Research Laboratory - V. G. Sprague

At Burlington, Vermont

Seedings of major legumes, grasses and weeds were again made on four dates (December, March, April, May).

Seeds of the December seeding made on frozen ground were badly scattered by heavy rains. Therefore, data from this date of seeding are limited. From March plantings, reasonably good stands of both legumes and grasses were obtained from planting on frozen ground. Weeds tended to group into two categories; those responding best to a seeding on frozen ground (Group I, including Ragweed, Redroot Pigweed, Chickory, Buckhorn and common plantain) and those doing best when planted in the spring (Group II, including Mustard, Barnyard grass and Lady's Thumb).

Harvests were made of individual plants on July 25, 1951--from each seeding date, and plant weights were obtained (dry matter basis). Results are shown in Table 4.

Table 4. Dry weight in grams of 10 plants, harvested July 25, 1951 from seedings made in December and March (on frozen ground) and in April and May (conventional seeding conditions)

Species	December	March	April	May
Grasses	12.1	19.4	11.1	10.4
Legumes	89.9	55.9	25.4	20.3
Weeds (Group I)	143.9	110.2	69.3	54.4
Weeds (Group II)	26.4	54.1	33.6	112.2

More plants grew (became established) with the conventional planting where seeds were covered with soil in April and May than when seeded on frozen ground (December and March). However, most of the plants which grew under the latter conditions were much larger than the later plantings in April and May.

RUNOFF FROM PERMANENT PASTURES IN PENNSYLVANIA

Leaders: For the Pennsylvania Agricultural Experiment Station - R. B. Alderfer
For the Pasture Research Laboratory and the Division of Soil Management and Irrigation Agriculture - R. R. Robinson

Trials on a permanent pasture on Hagerstown silty clay loam showed that the infiltration capacity of the soil may vary widely throughout the year. A highly compacted area showed marked improvement in infiltration capacity from late fall to early spring.

In contrast to results obtained last year the use of an aerifier on a compacted sod greatly decreased runoff losses during simulated rainfall. The aerifier used this year, however, was much larger and heavier than the one used last year. An examination of the soil indicated that on highly compacted pastures where the infiltration capacity of the untreated soil was low, water entered the holes made by the aerifier and then moved laterally through the soil.

SOIL FERTILITY AND SOIL MOISTURE RELATIONS IN GRASSLANDS IN MAINE AND RHODE ISLAND

Leaders: For the Maine Agricultural Experiment Station - Charles H. Moran and P. N. Carpenter
For the Rhode Island Agricultural Experiment Station - Donald A. Schallock, Irene H. Stuckey, and Milton Salomon
For the Division of Soil Management and Irrigation Agriculture and the Pasture Research Laboratory - R. R. Robinson

The results of a survey of soil fertility levels on dairy farms is being followed by field plot experiments on new seedings of bromegrass-Ladino clover to determine the responses to fertilizer on soils of varying initial soil fertility levels. Experiments were started this year on 4 farms in Maine and 2 in Rhode Island. The experiments are designed to evaluate the response to phosphate when lime and potash are not limiting and similarly to evaluate the response to potassium when lime and phosphate are adequate. In Maine the response to nitrogen will also be determined. Data on yield and botanical composition will be supplemented by data on potassium removal by the crop and on the effect of fertilization on soil fertility levels as indicated by laboratory tests.

PART II

RESEARCH AT THE LABORATORY

CYTOGENETICS AND BREEDING

Varietal Improvement in Dactylis glomerata, Bromus inermis and Trifolium repens

Inbreeding in Dactylis glomerata: Yields were taken in 1951 from space planted progenies representing crosses of I_5 lines and their parental clones onto two testers (1949 Annual Report, page 39 and 1950 Annual Report, page 29). The preliminary results suggest that there is a tendency to obtain good combining inbred lines from good combining parents.

In order to complete the diallel crossing program initiated in 1950 (1950 Annual Report, page 29) a total of 428 plants were brought into the greenhouse for crossing. This material includes 14 parental clones and 40 inbred lines in the I_5 and I_6 generation.

Bagged seed was obtained from 115, I_6 lines (1950 Annual Report, page 30) to continue the study.

Comparison of clonal, polycross and single crosses progeny tests for the evaluation of individual plants of Dactylis glomerata: Yield data and visual observations on height vigor and disease were obtained in both the seeded and spaced planted portions of this experiment (1949 Annual Report, page 40).

The number of entries in the two types of polycross nurseries used in this investigation appeared to have little effect on the progeny results. Although the averages of the single crosses having a common parent gave results similar to the polycross progenies, effects of specific combining ability were noted. This suggests that single cross data may be useful in grouping selected clones for the production of synthetic strains.

Tiller plots proved to be more satisfactory in evaluating clones for yield than space planted plots. The self-fertility status of the parents was not an important factor in the yield performance of their progenies.

Seedling vigor tests, planted in flats in the greenhouse were compared with the field results. There were four replications of eight plant plots. Two tests were conducted corresponding to the early and late maturity groups included in the field experiment. The entire seedlings were harvested 57 days after planting, and the dry weight of roots and tops was recorded separately for each plot. Some association was noted between seedling characters and field performance but the results were inconclusive.

The field experiment will be harvested again in 1952 and the seedling tests repeated.

Comparison between methods of progeny testing: Seed harvested in 1950 from the 1949 Polycross Nursery (1948 Annual Report,

page 4) was used to establish this experiment. Additional seed sources were added to make 121 entries. The progenies were planted in the spring of 1951 in broadcast plots (4 replications) and as spaced plants (10 plants per plot and 4 replications). An 11 x 11 lattice design was used for both trials. The seedling vigor of these progenies will be evaluated in the greenhouse.

The results obtained from the three methods of progeny testing will be compared, and superior clones selected on the basis of the overall results. In addition, clones will be selected for superiority with respect to one or more characters (total yield, disease resistance, leafiness, etc.) within each of the testing methods, and these selections established in independent isolation plots for the production of synthetic strains. The direction of selection and the usefulness of the various methods will be compared according to the performance of the synthetics in seeded plots.

Selection for increased seedling vigor in Bromus inermis: Polycross progenies from 35 clones included in the 1945 bromegrass polycross (1947 Annual Report, page 29) were planted at a depth of 2 inches in a greenhouse bed. The soil was compacted and watered to promote the development of a crust. Significant differences were found between lines in percentage emergence. The test was repeated 3 times.

Seedlings selected from these and similar tests will be used to examine the feasibility of improving seedling vigor.

Selection for persistency in Trifolium repens: Seed from crosses between good and poor clones, classified on their reaction to low light intensity, (1950 Annual Report, page 30) has been established in flats for greenhouse testing.

Isolation of Ladino clover plants resistant to Sclerotinia trifoliorum: The preliminary inoculation tests of single crosses (resistant x resistant, resistant x susceptible and susceptible x susceptible) indicated that progenies from clones classified as having some resistance to Sclerotinia had a somewhat higher percentage of survivors than progenies involving susceptible parents. At present over 12,000 seedlings are in the process of testing. Survivors from these tests are being reinoculated and the better plants kept for further crossing.

Sixteen clones representing some of the resistant and susceptible parents used in producing the above single crosses, were planted in clonal plots in the spring of 1951 (5 x 5 foot plots, with 4 replications). Two replications were inoculated with Sclerotinia in the fall of 1951.

Genetic Investigations

Inheritance of maturity in Dactylis glomerata: Notes were taken on time of heading and flowering in 1951 (1950 Annual Report, page 30). The results from the three experiments have been analyzed statistically but summaries have not been completed.

Inheritance of quantitative characters at the diploid and tetraploid levels in Dactylis sp.: Crosses are being made during the winter of 1951-52 to complete the necessary generations required for this experiment (1950 Annual Report, page 31).

Inheritance of male sterility in Dactylis glomerata: Notes were obtained from the planting established in the spring of 1950 (1950 Annual Report, page 31). These data have been summarized together with previous information (1945 Annual Report, page 35, and 1947 Annual Report, page 31). The following hypothesis has shown relatively good agreement with the observed results. The expression of male sterility is governed by the interaction of a factor for sterility and the appropriate cytoplasm. The sterility factor is completely dominant in presence of a dominant modifying factor but only partially dominant when the modifying factor is homozygous recessive, i.e. sterile (quadruplex and triplex), sterile minus or sterile (duplex), and fertile minus or fertile (simplex).

The inheritance pattern of male sterility is evidently quite complex, a fact which will limit its practical application. It might be utilized successfully, however, in an interspecific hybridization program or in making single and three-way crosses.

Inheritance of leaf coloration in Trifolium repens: Preliminary data has been obtained on the inheritance of purple midrib, purple fleck and purple leaf (1950 Annual Report, page 32). The inheritance pattern appears to be relatively simple for these three characters. Modifying factors are undoubtedly involved and purple fleck may be conditioned by complementary factors. Additional crosses are being made in the greenhouse during the winter of 1951-52, in order to determine the relationship that exists between the genes governing the above characters and those conditioning pink flowers, seed color and white center leaf.

Cytological Investigations

The significance of temperature in interpreting micronuclei determinations: The frequency of micronuclei at the quartet stage is a common measure of meiotic instability. It has been recognized, however, that the frequency of micronuclei is influenced by environmental conditions, especially temperature. Therefore, a limited study was conducted to determine the significance of this factor in collections made in the field, where plants are often subjected to a wide range of environmental conditions.

Four collections of duplicate heads were obtained from five clones of orchard grass during the period from June 2 to June 9.

The frequency of micronuclei was found to be more closely associated with the average temperature 48 to 72 hours prior to each collection than with the average temperature 24 hours preceding collection. Although the date of collection influenced the degree of instability the comparative results among plants remained the same.

Polycross tests of hexaploid Dactylis glomerata: No obvious relationship was found between the degree of meiotic irregularity and the self-and open-pollinated seed set of the hexaploid clones (1950 Annual Report, page 32). A composite seed lot from the hexaploid polycross was included in an orchard grass yield trial. The preliminary results obtained in 1951 were not encouraging.

Hybridization of Lolium perenne and Festuca elatior: The results of the hybridization program conducted in 1951 were very promising. Examination of plants resulting from crosses at the diploid and tetraploid levels has not been completed. Eight triploids (2n = 21) have been isolated from the cross between diploid perennial ryegrass and tetraploid meadow fescue. Additional crosses involving tall fescue (2n = 42) will be made during the winter of 1951-52.

Interspecific relationships in Bromus sp.: Hand emasculation appeared to give more consistent results than bulk emasculation with hot water (1950 Annual Report, page 33). A large proportion of the seed was poorly developed but nutrient media has been utilized successfully in obtaining fair germination. To date, the effectiveness of the crossing program cannot be evaluated as most of seedlings have just been transferred to the greenhouse. Additional crosses will be made in the winter of 1951-52.

Interspecific relationships in Phalaris sp.: The somatic chromosome numbers of seven species of Phalaris are shown in the following table. Several aneuploid plants were found in Phalaris arundinacea. In the sample studied 9.14 per cent of the plants varied from the expected chromosome number of 2N = 28. The frequency of aneuploids in the seven collections (17 collections were represented) that contained 12 or more individuals ranged from 0 to 15 per cent).

The meiotic behavior of Phalaris arundinacea together with the chromosome numbers observed, suggests that two factors may be contributing to aneuploidy. The 35 chromosome class may have resulted from non-reduction and subsequent crossing of the resulting hexaploid with normal tetraploids, events which would eventually contribute to a wide diversity in chromosome number. Further, the failure in some plants, of one or more chromosome pairs to become properly oriented at metaphase I may result in the addition or loss of one or more chromosomes. The four tetraploid species investigated behaved cytologically like allopolyploids.

The interspecific hybridization program is being continued during the winter of 1951-52 (1950 Annual Report, page 33). The possibility of using continuous emasculation is under investigation.

Table 5. Chromosome numbers determined for seven species of Phalaris

Species	Number of Plants	Chromosome Number 12	14	27	28	29	30	31	35
P. arundinacea	186			1	169	10	2	1	3
P. californica	30				30				
P. canariensis	60	60							
P. coerulescens	30		30						
P. minor	60				58	2			
P. paradoxa	88		88						
P. tuberosa	3				3				

PATHOLOGY

Stemphylium leaf spot of red clover

Stemphylium leaf spot (Stemphylium sarcinaeforme) is found in most fields of red clover in northeastern United States. The pathogen may kill many of the lower leaves and petioles, particularly in late summer. In a series of tests nineteen U. S. and foreign varieties of red clover were inoculated. Although none was highly resistant, the foreign varieties were much more susceptible than those from this country. Of the latter group the local adapted varieties, particularly Pennscott and Kenland, were less susceptible.

Studies on Pseudopeziza medicaginis and Ascochyta imperfecta

Studies are being continued on Pseudopeziza leaf spot and black stem of alfalfa in relation to their economic importance, the selection of highly resistant lines, and interpretation of the inheritance of resistance. To determine the amount of damage to the quantity and quality of hay a spaced plant experiment was established in the spring of 1951 which consisted of clones classified as resistant, intermediate and susceptible to the two diseases. The plants were inoculated with the two fungi; attempts were made to control the disease in 4 of the 10 replications in the test with organic chemicals. However, due to the very dry growing season the disease incidence was insufficient for differential disease records. The plots will be held over until 1952 and records taken of individual plant yields and leaf/stem ratio determined by samples taken from each plot.

During the winter of 1950-51 selfs and crosses were made using clones which varied in resistance and susceptibility to the two pathogens. The S_1 and F_1 seed were planted in flats and the seedlings inoculated with Ps. medicaginis. After readings were taken the plants were clipped and inoculated with As. imperfecta. Plants which showed no lesions after each test were repotted for further inoculations. The highly resistant or immune plants will be used for crossings in the determination of the inheritance of resistance to the two pathogens. It is hoped that higher resistance, particularly to As. imperfecta, may be obtained from

the progenies of our present resistant clones. More extensive crosses are planned for the winter of 1951-52.

Stemphylium leaf spot and stem canker of birdsfoot trefoil

A disease causing a leaf spot and stem canker of birdsfoot trefoil (Lotus corniculatus) was found last summer in seven northeastern states. The leaf lesions are round, reddish brown sunken areas approximately 1-5 mm. in diameter. Later the necrotic area increases slightly in size and becomes lighter, however, the leaves often drop before this stage. On the stems the copper-colored elongated cankers often reach 20 mm. in length. Older lesions develop grayish centers and sometimes completely girdle the stems. An unidentified species of Stemphylium was isolated repeatedly from the leaf and stem lesions and upon reinoculation produced lesions similar to those observed in the field. The conidia are somewhat similar to S. sarcinaeforme (not echinulate) which causes a leaf spot of red clover, however, immature fruiting bodies are found in the culture of the trefoil isolates. In several inoculation experiments the isolates from birdsfoot trefoil failed to infect red clover and alfalfa and isolates from these plants did not attack trefoil. The isolates from trefoil vary greatly in rate of growth on culture media; but maximum growth occurred at 22-25°C. Further cultural studies are in progress and attempts are being made to produce mature perithecia.

Purple leaf spot of orchard grass

A detailed study is being made of this disease and the causal organism (Stagonospora maculata). The fungus has been induced to sporulate in culture and on greenhouse plants for the first time. In cultural studies greatest mycelial growth was obtained at approximately 25°C while best sporulation was at 22-25°C.

The optimum temperature for infection is 22-25°C. The fungus enters the leaf tissue directly through the epidermis and through the stomata. The pathogen overwinters in the orchard grass stubble; pycnidia with viable spores have been found in the early spring.

Helminthosporium leaf streak of timothy

A leaf disease of timothy was found last summer in a field near State College. The lesions ranged from tiny oblong necrotic areas to long streaks surrounded by a conspicuous chlorotic zone. A species of Helminthosporium was isolated from the lesions and in reinoculations produced symptoms similar to those found in nature. The characteristics of this species did not agree with those previously reported on timothy. In preliminary investigation the fungus agreed closer to H. catenarium than the other known species. Further studies on the identification and etiology of the pathogen are in progress.

Physiology of fungi

In cooperation with the Department of Botany, The Pennsylvania State College, experiments are in progress to determine the ability of some fungous pathogens of forage crops to utilize amino acids as the

source of nitrogen, and also to study the effect of certain B vitamins, and the coenzyme pyridoxal phosphate on amino acid utilization by these fungi. Some quantitative work has been done with three species of Helminthosporium, and two Sclerotinia species. Twenty forage crop pathogens have been cultured on 3 media as a screening technique aimed at finding those isolates which are deficient in amino acids, B vitamins, or both. Many more isolates will be tested in this way, and certain ones which appear deficient will be selected for more detailed nutritional studies. The work is concerned with phytopathogenic fungi, and has as its ultimate aim the increase of our fundamental knowledge of the pathogen-suscept relationship.

Helminthosporium on grasses

Over 40 species of Helminthosporium found on grasses have been obtained from various parts of the United States. These were studied culturally and twenty-six sporulating species classified according to spore morphology. From a study of a limited number of isolates of the same species, the data indicate that the morphology of the spores is constant enough to separate species. A key has been prepared based on spore characteristics from host tissue as previously reported in the literature. This study was made and the results presented as a Master's Thesis by a graduate student in the Botany Department.

PHYSIOLOGY AND BIOCHEMISTRY OF PASTURE PLANTS

Carbohydrate studies on grasses

Investigations have been inaugurated on the isolation and characterization of the polysaccharides of the forage plants. A beginning was made with the heni-cellulose of orchard grass from three samples of a single clone harvested at different stages of maturity, namely at the vegetative, half-emerged, and flowering stages. The samples were dried, ground, extracted with a mixture of alcohol and benzene and with a warm solution of ammonium oxalate. They were then treated with sodium chlorite to solubilize the lignin and to leave as a residue holocellulose, consisting of cellulose and heni-cellulose. One hundred grams of grass yields about 55 grams of chlorite holocellulose and from this about 20 grams of hemicellulose are usually obtained by methods of alkaline extraction followed by precipitation. At the present time attempts are being made to assure the purity and integrity of a number of hemicellulose fractions on which chemical analysis will be made.

A report entitled "An improved method for the rapid extraction of plant sugars for analysis" was presented as a Master's Thesis to The Pennsylvania State College.

Relationship of reserve carbohydrates to reproduction in orchard grass

A preliminary experiment was conducted in the greenhouse to study the relationship that exists between reserve carbohydrates in orchard grass and initiation of reproductive primordia.

Each of the four clones of orchard grass (2 early and 2 late naturing clones) were subjected to the following treatments;

1. Short day 50° followed by Long day 75°
2. Short day 50° followed by Long day 50°
3. Short day 75° followed by Long day 75°
4. Short day 75° followed by Long day 50°
5. Short day 50° followed by Short day 75°
6. Short day 75° followed by Short day 75°

The early and late clones in selected treatments were sampled at four dates (7, 10, 17 and 25 days after being subjected to 16-hour days). Reducing sugars, sucrose and fructosan were determined in each clone.

Marked differences in the percentage of these reserve carbohydrates accompanied the initiation of reproductive primordia and heading. It would appear, however, that these changes are primarily related to vegetative development and rapidity of growth and not necessarily to reproductive development.

Plant Climate Studies

Air temperature studies in the microclimate were continued during 1951. Air, plant, and soil temperatures were measured with thermocouples from November 1948 to November 1951, and these data were critically analyzed. The following relationships were found to exist.

Under clear conditions, air temperatures during the day near the ground or the effective surface are usually higher than those at standard height (5 feet). During the night the reverse is true. Insolational heating and radiational cooling of the surface are primary causes of this relationship. Daytime air temperatures 3 inches above Kentucky bluegrass sod may be as much as 12 degrees F. higher than those at standard height, whereas night temperatures may be 6 degrees F. lower. Minimum nightly temperatures 1-1/2 inches above the ground over Kentucky bluegrass sod are often 2-3 degrees F. higher than those at 3 inches.

During the summer, cloud cover reduces macro- and microclimatic temperature differences to 1/3 or 2/3 of those under clear conditions; during the winter, differences are practically eliminated. Rain produces isothermal conditions or may depress temperatures near the ground 1-2 degrees F by evaporation. Wind decreases differences by mixing air "strata" of different temperatures. Cold air masses intensify summer daytime lapse rates. Dry air promotes radiation exchange, and thus encourages microclimatic temperatures extremes.

Air temperatures near the ground respond more rapidly and extensively to changes in radiation than those at standard height, and are consequently more variable. Greatest wind speed and air temperature fluctuations are found over the mid-day period.

Mean monthly maximums 3 inches over Kentucky bluegrass are usually

5-6 degrees F higher than those at standard height in the summer and are similar to those at standard height in the winter. Mean monthly minimums are consistently 2-3 degrees F lower throughout the year. Snow cover acts as insulation, lowering the mean maximums and raising the mean minimums at the 3 inch level. Monthly max.-min. means at 3 inches are usually 1-2 degrees F. higher than those at standard height during the hottest summer months and 1-2 degrees F colder during open winters.

Greatest daily temperature extremes are found nearest the effective surface, whether soil or vegetation. Daily range is diminished within alfalfa vegetation, since the top of it constitutes the effective surface. Exposed Ladino clover stolons growing in contact with bare soil have approximately the same temperatures as the soil surface. Temperatures of 125°F. occurred in the stolons on several bright days in August while at the standard height, air temperatures of 84°F. were recorded. Air temperatures 3 inches above bare soil were 6-12 degrees F lower than those of the soil surface at the time of the maximum, and 2-3 degrees lower at the time of the minimum. Stolon temperatures have exhibited temperature ranges as great as 60 degrees F during 24 hours.

Mean temperatures calculated from max.-min. readings are usually higher than those calculated from hourly or bi-hourly readings, when measurements are taken in the microclimate. Largest differences occur in places of greatest temperature extremes. Similar results are obtained from the two methods at standard height.

Relative humidities under field conditions at 3" and 5 ft. above a Kentucky bluegrass sod were calculated from dewpoints and air temperatures. These were recorded at 2-hour intervals during the day and 3-hour intervals during the night. These data have indicated that the dewpoints at both the 5 ft. and 3 inch heights are associated primarily with the moisture content of the prevailing air mass, but that at the 3-inch height a diurnal cycle also occurs. On a clear summer day the dewpoint at 3 inches is higher than at 5 feet and falls below that at 5 feet during the night. Also the dewpoint within a stand of alfalfa during the day exceeds that at the 5 foot height over Kentucky bluegrass.

Velocity of air movement was recorded during the summer with hot wire anemometers above and within vegetation. Wind velocity is greatly reduced near the ground or vegetative surfaces and is very low in alfalfa at the hay stage. The magnitude of these differences are indicated under conditions that occurred in early September.

Table 6. Velocity of air movement in and above vegetation

Date, 2 p.m. on	60" above KB sod ft. per min.	3" above KB sod ft. per min.	3" above soil in Alf. 12" tall ft. per min.
9/8 /51	187	105	8
9/5/51	275	152	33
9/10/51	578	225	43

Relationship of temperature to time of flowering

A preliminary experiment designed to study the relationship of temperature to time of flowering was conducted in the greenhouse during the winter of 1950-51. Eight clones of orchard grass ranging in field maturity from early to late were selected for this study. Single tillers were established in 4" glazed pots, and eight replications maintained at each of two temperatures (50° and 75°F.) under short days for a period of 60 days. Four replications of each clone were then interchanged to give four treatments (maintained at 75°F; maintained at 50°F; short day 75°F - long day 50°F; short day 50°F - long day 75°F) and the entire experiment subjected to a 16-hour day.

The results can be summarized as follows: (a) floral primordia were not initiated when the plants were maintained at 75°F, (b) high temperature pre-treatment delayed initiation of floral primordia at 50°F and reduced heading and flowering, (c) low temperature pretreatment followed by high temperatures and long days resulted in rapid initiation of floral primordia, heading, and flowering, (d) continuous low temperatures did not retard the initiation of floral primordia excessively but delayed heading and flowering, (e) vegetative development (number of culms) was enhanced when the plants were maintained at 50°F.

The above experiment is being repeated using late and early clones of five species (orchard grass, meadow fescue, bromegrass, timothy, and reed canary grass) and nine treatments. The treatments consist of all combinations of three short day pretreatment temperatures (55°, 65° and 75°F) and three long day (16 hour) temperatures (55° continuous 75° continuous, and alternating - 75° day and 55° night).

Fourteen clones of orchard grass were grown in the greenhouse under day lengths of 12, 12-1/2, 13, 13-1/2, 14, 14-1/2 and 15 hours. The results were essentially the same as those reported in 1949 (1949 Annual Report, page 51).

Growth responses of Ladino clover clones under low light intensities

The results obtained from experiments conducted in 1949 and 1950 were similar (1949 Annual Report, page 49, and 1950 Annual Report, page 37). The possibility exists, however, that a portion of the differences found between clones may be attributed to a higher level of reserves in some entries. In order to examine this possibility twenty-four clones of Ladino clover, selected on the basis of survival under low light intensities, were subjected to three clipping treatments. The plants were established in 4" glazed pots and 4 replications of each clone given the following treatments 2 weeks before the initiation of the experiment: (1) not clipped, (2) clipped, (3) transplanted and clipped. The clones in all three treatments were clipped back to the level of pots when they were exposed to low light intensity.

The rapidity of death and the percentage of dead plants were greatest in the more severe treatment (transplanted and clipped twice). At the termination of the experiment the twenty-four clones could be arranged in 4 categories; (a) clones alive and vigorous in all 3 treatments, (b) clones alive in treatments 1 and 2, but not 3, (c) clones alive in treatment 1, but not 2 and 3, and (d) clones dead in all 3 treatments. In general, clones that had been previously classified as "good" fell in the (a) and (b) categories while "poor" clones occupied the (c) and (d) categories.

The availability of potassium to Trifolium repens in grass-clover associations

Greenhouse trials were conducted to determine the effect of six grass species on the availability of potassium to Ladino clover. The grass species were Kentucky bluegrass, bromegrass, tall fescue, orchard grass, timothy, and tall oatgrass. In one trial the grasses and clover were seeded at the same time, whereas in a second trial the clover was seeded after the grass had become well established. Potash fertilization ranged from none to very high rates. All pots received phosphate and the soil had previously been limed. Clippings were made every 4 or 5 weeks after the plants became established. Yield data, percentage potassium content of the grass and the Ladino clover, and total potassium removal indicated that in pots receiving no potassium the establishment and growth of Ladino was limited by a deficiency of potassium even though the associated grass did not respond to potash fertilization. At high levels of available potassium the growth of clover seedlings was markedly increased. But with very vigorous growing grasses such as tall oatgrass and orchard grass the growth of clover seedlings in the established grass sods was relatively poor even though the potassium content of the clover indicated that potassium was adequate for good growth. A detailed report of this work was presented as a Master's Thesis to the Pennsylvania State College.

Rate and frequency of potash application on Dactylis glomerata

Potassium uptake by orchard grass on Hagerstown silt loam was determined on plots receiving potash fertilizer at different rates and frequencies (1950 Annual Report, pages 37, 38). All plots received lime as needed and moderate applications of phosphate and nitrogen. Both soil tests and yield responses to potash fertilization indicated that the soil was low in available potassium.

The results indicate that for this type of soil the effect of an application of potash lasts longer than often has been assumed for soils in the Northeast. The total potassium removed in the herbage in 1950 was 53, 85, and 78 pounds per acre respectively for plots receiving no potash, 50 pounds K in 1949 and again in 1950, and 100 pounds of K in 1949 only. The corresponding values for percentage potash content of the herbage in the first cutting in 1950 were 1.70, 2.62 and 2.38 respectively. Thus, it is apparent that where 100 pounds of K was applied in 1949 the carryover effect in 1950 was very pronounced.

Establishment of *Trifolium repens* in a *Dactylis glomerata* sod

In April 1951 a broadcast seeding of Ladino clover without cultivation was made in an old orchard grass sod on Hagerstown silt loam to determine the effects of potassium fertilization, nitrogen fertilization, clipping treatment, and irrigation on the establishment of Ladino clover. Treatments consisted of four levels of potash, two levels of nitrogen, and four clipping treatments in a factorial design. Potash and nitrogen fertilization ranged from none to high. Clipping treatments were designed to simulate (1) hay and aftermath, (2) rotation grazing, (3) very severe clipping, i.e. clipping to a height of 2 inches when 3 to 4 inches high, and (4) very severe clipping until the clover reached a height of two inches. The effect of irrigation was determined on plots cut for hay and aftermath.

Stands of clover on the non-irrigated series ranged from very good to extremely poor. The best stands were obtained on the plots that were very severely clipped - 7 cuttings during May and June (because of the very dry weather during midsummer and fall the actual clipping practices were very similar on the plots very severely clipped all season and on those very severely clipped until the clover was 2 inches high). Under these two clipping treatments, fair stands of clover were obtained even where a high level of available nitrogen was maintained. Clover was almost a complete failure on the plots receiving nitrogen fertilizer and cut for hay. On the series cut to simulate rotation grazing fair stands of clover were obtained at low nitrogen levels, but at high nitrogen the stand was poor.

Potash fertilization had relatively little effect on clover establishment indicating that on these plots available potassium was not an important limiting factor. Potassium determinations on soils and plants are not completed.

Irrigation greatly increased the growth of Ladino clover, but did not result in good stands of clover under unfavorable clipping management and high nitrogen fertilization.

The results indicate that under certain management practices it may be possible to reestablish Ladino clover in an orchard grass sod without tillage.

PART III

PASTURE RESEARCH AT STATE STATIONS

Storrs (Connecticut) Agricultural Experiment Station

Title: Alfalfa Experiments

Leaders: B. A. Brown and R. I. Munsell

(a) Fertilization: In the fifth harvest year, plots without additional P since seeding had good stands and yielded as well as those which had received superphosphate annually. In marked contrast, omitting potash since the preseeding application of 60% muriate of potash at 600 pounds resulted in only 20 per cent stands and about two-thirds as much dry matter as where 200 pounds of 60% muriate of potash was applied each year. Even omitting the potash in only the first harvest year (1947) was almost as disastrous as omitting it since before seeding. Somewhat poorer stands and yields occurred in 1951 where little or no boron had ever been applied. Omission of Mn, Cu, Zn or Mo had no noticeable effects.

For the first time in this experiment, fertilizer N was responsible for an increased yield of about 10 per cent. This was due to the thinning of the alfalfa by heaving in the winter of 1950-1951 and the consequently greater proportion of volunteer grasses on all plots.

Total acre yields of dry matter from three cuttings varied from 49 to 88 cwts. and averaged 74 cwts. for the twenty-two fertilizer treatments. The five-year average yield of dry matter is 84 cwts. or very close to 5 tons of hay.

The analyses of pure alfalfa from the first and second cuttings of 1950 showed that the omission of potash since 1946 was responsible for concentrations of K in the dry matter of about 1 per cent and the very poor stands on those plots support the New Jersey finding that 1 per cent K is dangerously low. The average K content of the alfalfa fertilized annually with muriate of potash was about 1.5 per cent in 1950. As in previous years, the concentrations of Ca and Mg increased with decreases in percentages of K.

The average B content of pure alfalfa from the first and second cuttings was 13 p.p.m. where no borax was added in 1946, 15 p.p.m. with 10 pounds, 16 p.p.m. with 20 pounds, and 20 p.p.m. with 40 pounds of borax. Symptoms of B deficiency were very prevalent on the no-borax plots.

(b) Varieties: Although the winter of 1950-1951 was unusually mild and with little penetration of frost, heaving caused marked reductions in the stands of the 1947 seeded varieties. In October 1951, the French variety, "DuPuits", still had the second best average stand (70 per cent) but one of its replicate plots, located nearest land previously planted to alfalfa, had thinned during the summer of 1951 to 25 per cent. Wilt appeared to be the cause of this sharp decline. On the same date, a nearby

plot of Ontario Variegated, a wilt susceptible variety, had only a 5 per cent stand.

The four-year average yields of dry matter varied from 72 cwts. for Ladak to 90 cwts. for DuPuits. Buffalo and Ranger were midway between those extremes. Atlantic was second to DuPuits with 85 cwts. and had the best average stand (76 per cent) in October 1951.

Among the twenty-three alfalfa varieties seeded in 1950, it was observed that Narragansett had the least leaf-spot and as noted in the older tests, Ranger was affected by this disease as much or more than any variety excepting Talent.

Title: The Maintenance and Improvement of Pastures

Leaders: B. A. Brown and R. I. Munsell

(a) The Effects of Fertilizer Treatments on the Soil, the Flora, and the Production as Measured by Grazing: The twenty-eight year average relative yields as measured by grazing from a few long continued fertilizer treatments on untilled, unseeded permanent pastures are listed below:

No fertilizer	- 100
P	- 155
PL	- 200
PLK	- 225
PKN	- 272
PLKN	- 295

Omission of lime since the one ton application in 1924 has resulted in the appearance of some moss, but not in any reduction in yields. Omission of P since 1924, when 500 pounds of 16% superphosphate was added, has caused a very weedy turf and an average reduction in yields of 25 per cent during the last ten years.

The annual application of limestone at 1000 pounds, 46% superphosphate at 100 pounds, and 60% muriate of potash at 100 pounds since 1942 has produced a turf with somewhat more native white clover and Kentucky bluegrass and 16 per cent more pasturage during the last ten years than the less frequently fertilized plot, which has received the same materials about once in three years, but totaling about 60 per cent as much limestone, superphosphate or potash.

One of two plots, which had received only superphosphate until 1942 and yielded practically the same for eighteen years, has been given small annual applications of limestone the last ten years, totaling over 3 tons. This lime has caused a ten-year average increase of 27 per cent in pasturage or an increase very similar to the early ones obtained in this experiment from adding limestone to the basic superphosphate treatment.

(b) The Adaptability of Varieties and Species of Grasses and Clovers for Pastures. The first Ladino clover seed to come into Connecticut arrived in 1929. In recent Greener Pasture Contests, fifty-five per cent of the grazed areas on the farms of County winners in the

State had been seeded with Ladino! Without any doubt, it is presently the best species for pasture.

In 1951, the management plots of Ladino-grass mixtures completed their thirteenth year. It was the second year of mowing all plots four times each season at the same time. This common management reduced further the marked differences in Ladino stands which existed at the termination of the differential cutting treatments continued from 1939 through 1949. Nevertheless, the former 8-2 and 10-2 inch plots still had in 1951, 40 per cent more Ladino and yielded 16 per cent more dry matter than the corresponding 8-4 and 10-4 inch ones. The above increases are based on the average results from Ladino-timothy and Ladino-orchard grass seedings. The differences were greater for the Ladino-timothy seeding where the timothy has been largely replaced by Kentucky bluegrass than on the Ladino-orchard grass plots. Incidentally, the yields of dry matter in 1951 were 33 per cent larger for the Ladino-timothy seedings and 20 per cent greater for the Ladino-orchard grass plots than in 1950.

With orchard grass, the "breeders" strain of Ladino (F.C. 23608) had about the same stands and yields as commercial Ladino in 1951.

For several reasons, it is very important to have at least a fair stand of a grass with Ladino. For example, in 1951, the average yield of dry matter for four Ladino-orchard grass mixtures, with considerable grass in the stands, was 27 per cent higher than the average for eight Ladino-brome grass seedings, none of which had what is considered desirable amounts of grass. These results and the many failures of farmers to secure good stands of bromegrass emphasize the need for an intensive study of the causes for poor establishment of that species.

A May 1951 seeding of birdsfoot trefoil and timothy reached a height of 6 inches by late July and supplied about 16 cow days of grazing per acre at that time. Subsequent growth was very slow and insufficient to justify another grazing period during that season.

Empire and Italian varieties of trefoil were included in an alfalfa variety test seeded in 1950. In 1951, the total yields of dry matter of the trefoils were practically the same and averaged 5500 pounds per acre. Under the same conditions, most of the twenty-three alfalfa varieties produced over 6000 pounds of dry matter and averaged 6400. From appearances, one would have "guessed" that the differences in favor of alfalfa were larger than actually found.

Because of serious competition from chickweed, yields were not determined in 1951 of the eight strains of trefoil seeded in 1950. The stands of trefoil improved sufficiently, however, to justify continuation of the test.

Ladino Fertilization: In the second harvest season, the Ladino-orchard grass seeding yielded less on the best of eight rock phosphate treatments than on the poorest superphosphate (46%) one. The average yield of the eight rock phosphate treatments

was nearly 20 per cent less than the average of seven superphosphate tests. Reducing or omitting limestone where rock phosphate was applied, reduced the stands and yields. (Original pH was 5.7).

In 1950 the herbage from plots with rock phosphate had the lowest content of P.

Fused tri-calcium phosphate, calcium metaphosphate, or potassium metaphosphate produced about the same results as 46% superphosphate. Several di-calcium nitrophosphates also produced practically the same yields as 46% superphosphate.

Among the potash treatments, the lowest rate--60 pounds of K_2O annually--resulted in the least Ladino and the smallest yield in 1951. The highest annual rate--240 pounds of K_2O--produced the largest yield, but 120 pounds of K_2O divided into four applications per season gave only 4 per cent less dry matter.

Ladino showed symptoms of K deficiency in the second harvest season where K_2O at 360 pounds was applied before seeding and none thereafter. Such deficiency symptoms did not appear where K_2O at 720 pounds was added before seeding.

In 1950, the concentrations of K in the herbage varied 100 per cent due to varying potash treatments. Limestone at 8 tons per acre did not decrease the absorption of K by the herbage, but heavy applications of potash did depress somewhat the concentration of Ca in the dry matter.

Delaware Agricultural Experiment Station

Title: Fertility Requirements of Legume and Grass Legume Mixtures

Leaders: W. H. Mitchell and L. J. Cotnoir, Jr.

In 1951, the second harvest season for the Ladino clover and orchard grass fertility study (1950 Annual Report, page 43) differences in dry matter yields were due largely to the complete fertilizer treatments. The only treatments producing highly significant increases in dry matter over the 0-100-100 which is recommended frequently for Ladino clover mixtures at the present, were those including 200 pounds of nitrogen with either 200 or 400 pounds of P_2O_5 and K_2O. Ten tons of manure reinforced with either 200 pounds of P_2O_5 or 200 pounds of P_2O_5 and 100 pounds of K_2O also resulted in a highly significant yield increase over the 0-100-100.

The 1950 harvests showed that 0-100-100 produced about as much dry matter as 0-200-200 or 0-400-400. The only treatments producing significantly more than the 0-100-100 were those receiving nitrogen. Fifty pounds of nitrogen being sufficient to produce a highly significant increase in yield over the 0-100-100.

Lack of response at the lower levels in 1951 was probably due to the very low rainfall during late July-August and September.

Although added nitrogen has reduced the amount of Ladino clover it has increased the percentage protein, and yield sufficiently to

far outyield the better balanced mixtures in yield of protein per acre.

Table 7. Effect of Fertilizer Treatments on Yield of Dry Matter, Protein, and Botanical Composition of Sod

Fertilizer Treatment Lbs.	Harvesting Date	Estimated Ladino Clover	Protein	Protein Lbs. per Acre	Dry Matter Tons per Acre
N, P_2O_5, K_2O		%	%		
	May 3	32	20.3	148.1	
	May 25	14	13.5	108.2	
0-200-200	June 18	14	15.7	109.3	1.89
	Aug. 9	37	14.5	222.7	
	April 26	19	22.1	155.4	
	May 10	22	15.0	145.1	
50-200-200	June 6	4	14.3	90.0	1.99
	Aug. 9	20	12.9	199.1	
	April 26	18	24.3	241.8	
	May 10	23	15.8	162.2	
100-200-200	June 6	5	13.9	106.9	2.14
	Aug. 9	21	12.3	184.9	
	April 26	4	28.5	386.4	
	May 10	8	21.0	304.9	
200-200-200	June 6	1	14.0	185.1	2.70
	Aug. 9	4	12.2	157.1	

Maine Agricultural Experiment Station

Title: Management Practices as They Affect the Productivity and Persistence of Ladino Clover-Grass Associations

Leaders: C. H. Moran, L. H. Taylor

A series of 12 pasture paddocks at Stillwater, in which there had been very little re-establishment of Ladino following severe winter injury, was reseeded with Ladino on March 19, 1951. (The paddocks were disced lightly during the previous fall.) Good establishment of clover was obtained on most areas.

Three uniform cuttings (5-30, 7-25, 9-10) were made on all fields. Yield values for each paddock were obtained by cutting two random strips 4.5' x 20'. Analysis of the data indicated that there were no significant errors due to this sampling technique. Average total production of dry matter was 4966 pounds per acre. Yields were not affected significantly by the grasses (timothy, brome, reed canary) which had been established in the original seeding.

Title: Fertilizer and Cultural Trials for Small Grains and the Establishment of Forage Seedlings

Leader: L. H. Taylor

A series of tests were conducted in which nitrogen was applied at the rate of 0, 15, 30 and 45 lbs. per acre to oats in which seedings of red clover had been made. In certain of the tests, the 30 and 45 lb. rates of N application definitely depressed the growth of the legume seeding up to the time that the oat crop was harvested. As the period between oat harvest and the first killing frost is relatively short in our growing season we think this depression of clover growth may be of importance but we need further information as to the relationship of clover growth in the year of establishment to winter survival and forage yield the following season.

In two field experiments, seeding rates of oats were varied and conventional seeding was compared to seeding in alternate drill rows as to their effect upon stand establishment of red clover. From these studies, supplemented with greenhouse experiments now underway, we have some data that indicate that with heavy nitrogen fertilization clover establishment is assisted by a lighter rate of seeding and by wider row spacings of oats and that oat yields are not significantly decreased. Other indications are that liming is beneficial to clover establishment on certain of our soils, that the shading effect of a luxuriant growth of oats is a severe limitation to clover growth and that oats exhibit significant competition with clover for factors other than light.

Title: Breeding and Evaluation of Forage Crops

Leaders: L. H. Taylor and C. H. Moran

Additional plantings of both grasses and legumes were made in the observational forage nurseries at Orono and Presque Isle in 1951. Winterkilling of legumes in the nursery at Orono was severe during the winter of 1950-1951. No serious winterkilling occurred in the nursery at Presque Isle. This was probably due to more adequate snow cover in Northern Maine.

Winter survival appears to be our most serious problem in the maintenance of legume stands. With this in mind, selfed and open-pollinated seedlings of alfalfa were established with seed of strains that had survived for a number of years under farm conditions in Maine. From this study we hope to discover if we have local ecotypes of alfalfa that have greater winter survival value under our conditions than strains commercially available.

Maryland Agricultural Experiment Station

Title: Orchard Grass and Bromegrass for Forage with Legumes

Leaders: A. W. Burger, T. S. Ronningen and A. O. Kuhn

Fourth harvest-year clipping yields on triplicate plots of orchard grass in mixture with alfalfa, red clover, and Ladino clover as compared to Lincoln bromegrass with those same legumes were 2.25

tons of dry matter per acre for the orchard grass plots and 2.00 tons of dry matter per acre for the bromegrass plots. The orchard grass plots were almost entirely orchard grass and Ladino clover in desirable grazing proportions while the bromegrass plots consisted of Ladino clover primarily. There has been little change in the botanical composition of these two mixtures from last year. Beef animals were used to graze the paddocks. The dry matter yields are based on 2 per cent moisture.

Title: Pasture Renovation Studies

Leaders: A. W. Burger, T. S. Ronningen and A. O. Kuhn

Renovation studies to compare various grass-legume mixtures and disking vs. shallow plowing for seed-bed preparation as well as fall vs. spring establishment have been continued.

The 1951 comparative yields in tons of dry matter per acre for the four most promising mixtures (eleven mixtures in the study) are given in the accompanying table.

The addition of red clover and alfalfa to the orchard grass-Ladino mixture increased the dry matter yields. This effect has been consistently reported for the 1949, 1950, and 1951 harvests on all of the plots being studied regardless of the time and method of establishment. Fall establishment by disking and spring establishment by shallow plowing were superior treatments, respectively, when comparing the yields from the plot groups seeded in the fall of 1949 and in the spring of 1950. However, the advantages of fall disking for renovation, insofar as dry matter yields are concerned, seem to have been cancelled out by the third harvest year. Fall seeded mixtures generally have been showing higher dry matter production than spring seeded mixtures. Rainfall was unusually low during the fall of 1951 and the dry matter yields were low likewise.

Table 8. Average production in tons of dry matter (2% moisture) per acre, 1951.

	Established in:						
	Fall of 1949 (Average of 2 locations)		Spring of 1950		Summary		
Mixture	Disked	Plowed	Disked	Plowed	Average Disked	Average Plowed	Average Disked and Plowed
Orchard Grass-Ladino	2.05	1.75	1.43	1.46	1.74	1.61	1.68
Orchard Grass-Ladino-Red Clover	2.14	1.94	1.62	1.82	1.88	1.88	1.88
Orchard Grass-Ladino Red Clover-Alfalfa	2.12	2.07	1.65	1.86	1.89	1.97	1.93
Tall Fescue-Ladino-Red Clover-Alfalfa	2.05	1.86	1.48	1.40	1.77	1.63	1.70
Average	2.09	1.91	1.55	1.64	1.82	1.77	1.80

	Established in:						
	Fall of 1948 (Average of 3 locations)			Spring of 1949			
Orchard Grass-Ladino	1.43	1.56	1.52	1.24	1.48	1.40	1.44
Orchard Grass-Ladino-Red Clover	1.56	1.48	1.38	1.55	1.47	1.52	1.50
Orchard Grass-Ladino-Red Clover-Alfalfa	1.62	1.88	1.57	1.55	1.60	1.72	1.60
Tall Fescue-Ladino-Red Clover-Alfalfa	1.56	1.42	1.60	1.49	1.58	1.46	1.52
Average	1.54	1.59	1.52	1.46	1.53	1.53	1.53

Title: Grass and Legume Combinations for Beef Production

Leaders: A. W. Burger, E. C. Spurrier, T. S. Ronningen and A. O. Kuhn

The 1951 results of the beef and dry matter production of five pasture mixtures are given in Table 9.

Table 9. Beef production and yield of certain pastures

Mixture	Beef Production (pounds of beef per acre)	Dry Matter Production Tons per acre (2% moisture) Cages	Strips
Orchard grass-Ladino clover	416	3.02	2.63
Tall fescue-Ladino clover	432	2.86	2.22
Kentucky bluegrass Timothy-white clover	374	2.13	1.70
Orchard grass-lespedeza	318	1.87	1.31
Tall fescue-lespedeza	220	1.46	1.03

The smooth bromegrass-Ladino clover mixture which was reported in the 1950 results has been replaced by tall fescue-lespedeza. Therefore, the data on the latter mixture represent the results for the first year of grazing while the data on the remaining four associations represent production results for the second year of grazing.

Title: Microclimatic Environment of Common Forage Species

Leaders: A. Morris Decker, T. S. Ronningen, H. C. S. Thom, Department of Geography, cooperating, and A. W. Burger

During the past year soil and air temperatures were obtained at various levels within a number of plots from the NE-10 Strain and Variety Test at the University of Maryland Plant Research Farm. (1950 Annual Report, page 50). Frequency distributions of these temperatures at two-hour intervals over weekly periods have been studied in some detail for the spring months. A complete study has not been made, but the investigation thus far suggests that leaf elongation of orchard grass during this period seems

to be a logarithmic function of temperature. Other species show a similar response. Temperature appears to be the one factor most limiting in the early stages of growth in the spring. As the season progresses, the importance of temperatures tend to decrease gradually until early May, when other factors such as soil moisture and nutrient supply become more important. The day temperatures appear to be more important than night temperatures in the spring. Using a base index between 38° and 42°F seems to best describe the relationships between growth and temperature accumulated as degree-days. Further investigations of these relationships are being made with the hope that the approximate temperatures at which growth is initiated and the rate at which growth increases with increased temperatures can be established. Frequency distributions are being used because it is felt a more accurate picture is obtained than when maximum, minimum and daily average temperatures are used. It was found that at the same temperature index (degree day accumulation) orchard grass was better able to take advantage of the increased temperatures in plots where nitrogen was applied in contrast to those plots where the nitrogen was supplied by the associated legume.* This same type of measurement will be made and the data analyzed for the spring months of 1952. *This increase in leaf elongation ranged from 0.25 to 2.10 Cm. per week.

There is a direct relationship between soil surface temperatures and those at the 3, 12, and 60 inch air levels. The maximum, minimum, and daily average temperatures at these levels were quite different. The results corroborate those reported by V. G. Sprague in the 1950 report. (1950 Annual Report, page 36 paragraph 3).

In addition to temperature data, observations on light, wind speed, precipitation, evaporation rates, relative humidity, and soil moisture have been made. Precipitation over the past year was near normal but its distribution was very abnormal. Rainfall was adequate throughout the winter and spring, with only a slight decrease during May, resulting in normal first-harvest yields. From the first to the second harvest, rainfall was more than twice the long-time average for the period, and almost ideal conditions existed for forage crop production. Excellent yields of all adapted species were obtained. Following the second harvest, however, and throughout the remaining portion of the season rainfall was far below normal and it came largely in numerous light showers so that much of the moisture evaporated directly from the soil surface. Small fluctuations of soil moisture at the three-inch level were noted but in general, the soil moisture was gradually depleted to near the wilting point in all plots at all levels. Temperatures, which were slightly above normal during this period, may have accentuated the effects of low moisture. Rainfall was near normal in November, but this was too late for any appreciable growth. The adverse conditions may have a pronounced effect on winter survival and spring growth of all species, especially Ladino clover.

A study to determine whether a relationship exists between temperature and heaving of forage species was initiated in the fall of 1951. Continuous soil temperatures at one-half and three-inch levels in plots of Ladino clover, orchard grass, orchard grass-Ladino, bromegrass-Ladino, alfalfa, bluegrass, and under bareground

conditions are being obtained. In addition, soil temperatures at the 10-inch depth are being obtained with a portable potentiometer. The heaving action is being estimated by measuring the movement of wooden doweling with diameters of 1/4, 3/8, 1/2 and 1-inch which were driven into the ground to depths of 4, 8, 12, and 16 inches. Plant measurements and periodic photographs are being taken to correlate these results with the behavior of the plants. Diameter of the doweling appears to have little effect on the amount of heaving while an indirect relationship between heaving and depth of doweling in the soil seems to exist. Stakes in the bareground plot at the four-inch depth have been almost completely heaved from the ground while those at 16 inches have moved least. Essentially no movement of stakes has taken place in the bluegrass plot. At no time thus far during the winter has the soil been frozen deeper than a few inches and only such shallow rooted crops as Ladino clover have shown heaving damage. Eighty to ninety per cent of the Ladino clover stolons have been heaved. Many of the stolons were left one inch or more above the surface of the soil exposing large portions of their main roots to the cold, dry winter winds. The heaving action appears to take place as the ground thaws. However, the soil surface and stakes may both heave as the ground freezes with the soil settling as thawing occurs. Only small areas of 6-8 inches in diameter which are devoid of vegetation were necessary to produce the same amount of heaving as on larger bareground plots.

It is planned to continue this portion of the study through the 1952-53 winter period.

Title: Alfalfa Variety Tests

Leaders: T. S. Ronningen and A. W. Burger

Williamsburg has been generally superior in yields during the third harvest year to other varieties under test in Maryland. The performance of this variety was particularly good in the Coastal Plain area of the State. Atlantic and Buffalo were dependable varieties at all locations with Atlantic being better adapted to conditions of the Maryland Eastern Shore and Buffalo being superior in the northern part of the State.* First- and second-year test results are promising for Narragansett. *Good yields of Kansas Common were obtained in the Coastal Plains area. Ranger produced well only in the northwestern part of the State.

Title: Red Clover Breeding
Leader: C. H. Liden

Tests were continued during 1951-52 on the development of lines resistant to southern anthracnose (Colletotrichum trifolii). Field selections were made from plants which had survived inoculation as 3 to 4-leaf seedlings in controlled temperature and humidity chambers in the greenhouse. Field selection was on the basis of forage quality and resistance to disease. Enough seed is expected to be available of these lines to make row plantings for hay and seed production evaluations in 1952-53.

Massachusetts Agricultural Experiment Station

Title: Field Bromegrass (Bromus arvensis) Its Uses and Potentialities

Leaders: William G. Colby, Mack Drake

The need for a cover crop on vegetable land which does not reseed itself if sown in late summer or early fall and thereby become a weed hazard has focused attention on an old but little known grass, Field Brome. In addition to its potentialities as a cover crop, Field Brome has excellent possibilities as a pasture grass for late fall and spring grazing for all types of livestock, including poultry. Our experimental trials with this grass thus far have been so promising, we believe that publication of our results is justified.

Plant Characteristics. Field Brome grass is a winter annual similar to winter wheat or winter rye. When seeded in late summer or early fall, it does not produce seed heads until late the following June. Where soil fertility conditions are favorable, it produces a dense, low, leafy growth in the fall and in early spring. Late in June, seed stalks are produced which grow to a height of from 2 to 3 feet. Field Brome does not have stolons or rhizones, but each plant tillers profusely, particularly at high levels of nitrogen fertilization. This accounts for its ability to make a dense ground cover in a very short period of time. Root growth is commensurate with top growth. It is very winter hardy and is also drought-tolerant.

History. It has been cultivated to a limited extent, particularly in the Scandinavian countries, for many years. Seed has been produced in Denmark. Introductions have been made into this country from time to time but it is only recently that promising uses for this grass have been found. C. L. Flint, Secretary to the Massachusetts State Board of Agriculture, mentions Field Brome grass in his book, "Grass and Forage Plants", published in 1867. The South Dakota Experiment Station reported Field Brome grass trials in 1901 (S. D. Agr. Exp. Sta. Bul. No. 69). The present investigations were begun with seed secured by the agronomy department from a commercial seedsman in Germany in 1937. A second lot of seed was obtained from the Royal Danish Agricultural Society in 1938. Since 1944 seed for all trial plantings has been supplied by the U.S.D.A. Soil Conservation Service Nursery at Big Flats, New York. Seed is not yet available commercially, but steps are being taken to get production seed started. Some commercial seed should be available by August 1952.

Uses. Perhaps the most promising use of Field Brome is on vegetable land as a winter cover crop. If seeded by September 1 it will produce a thick, heavy sod by May 1 the following spring. It is much more winter hardy than domestic ryegrass and more productive of organic matter than winter rye. A Field Brome grass cover crop seeded September 1, 1949 produced 2600 pounds (dry weight) of roots per acre compared with 1440 pounds for winter rye.

Most important of all, Field Brome does not become a weed hazard at any time if the land is plowed before late June.

Field Brome can be used for pasturing all types of livestock in late fall until freezing weather begins. Spring pasturing begins about the same time as for permanent bluegrass pastures and will continue for 6 to 8 weeks. The feed is palatable and nutritious when adequately fertilized. Grazing or ranging (in the case of poultry) can be heavy without seriously injuring the sod. Dry matter yields are high. A plot seeded August 21, 1950 produced 1640 pounds of dry matter per acre that fall and considerably more than a ton of dry matter the following spring. In addition to producing forage in late fall and early spring, Field Brome serves as a very successful smother crop for many undesirable weeds and grasses. Its rapid dense growth will eliminate such persistent grasses as Kentucky bluegrass, red top, bent grass, and witch or quack grass. This feature may make Field Brome extremely useful in grassland systems of farming where intertilled crops are not included in the rotation. Hay or pasture land which needs to be reseeded can be hayed or grazed and then plowed by July 1. Occasionally discings during July and early August will prepare a satisfactory seedbed for an August 15 seeding of Field Brome. The Field Brome can be grazed during the fall and through the following spring until about July 1. The Field Brome sod can then be plowed and a seedbed prepared for an August seeding of perennial hay or pasture grasses and legumes.

Rate of Seeding and Fertilization. We have used about 20 pounds of seed per acre for most of our seedings - 15 pounds might be sufficient. This grass is a heavy consumer of nitrogen. The 1950 plantings which were made on an old heavy bluegrass sod were fertilized with 1000 pounds per acre of a 5-10-10 fertilizer. Two topdressings of ammonium nitrate were made during the fall and one before grazing started in the spring. About 40 pounds of elemental nitrogen were applied at each time.

When Field Brome is used as a cover crop, supplemental nitrogen should be added, not only to grow the grass, but also at plowing time to facilitate the breakdown of the tough, heavy sod. If liberal quantities of a high nitrogen fertilizer are not used, serious nitrogen deficiencies will invariably occur with the succeeding crop.

Title: Sources of Fertilizer Phosphorus for Forage Crops: Superphosphate vs. Ground Raw Rock Phosphate

Leaders: Mack Drake, J. E. Steckel, John Parsons and William G. Colby

The present information on the relative availability of rock phosphate and superphosphate to hay and pasture crops in New England is inadequate. A field experiment was laid out near Amherst in 1949 on a Merrimac, fine sandy loam. The area had not been cropped for 20 years and was a bent grass - cinque-foil sod.

Nitrogen and potassium were very low, the pH was 4.8 and Truog phosphorus was 40 pounds. One ton of dolomitic limestone was plowed under and two tons were worked into the surface 3-4 inches. Alfalfa, timothy, and a Ladino clover-smooth bromegrass combination were seeded across phosphate treatments. Three rates of finely ground raw rock phosphate (2000, 3000, and 4000 pounds/acre were compared with two rates of 20% P_2O_5 superphosphate (1000 and 2000 pounds/acre). The combination treatment of 1000 pounds rock phosphate with 50 pounds of sulfur plus 500 pounds of superphosphate was included. Three rates of sulfur (0, 100, and 456 pounds/acre) were used with the 2000 pound rate of rock phosphate. Rock phosphate and sulfur were broadcast and disked into the surface 3-4 inches of soil. Pelleted superphosphate was applied in bands (7 inches apart and 3 inches deep) to minimize fixation.

Heavy applications of phosphate were made before seeding as no additional phosphate will be applied for the 5 to 6 year period of this experiment. Nitrogen and potassium were maintained at optimum levels by frequent topdressings. We expected the yields from rock phosphate to be relatively lower the first year. However, it is pointed out that 1949, the year of seeding was so dry that no yields were taken. Breakdown of organic matter during 1949 is believed to have increased the level of available soil phosphorus. By the second year when the first yields were taken, both the rock and superphosphate treatments supplied adequate phosphorus for plant growth. Phosphorus availability from the rock might not have compared as favorably if harvests could have been made in the first year.

Yields and phosphorus content of timothy are shown in Table 10. The application of 1000 pounds 20% superphosphate per acre increased both yield and phosphorus uptake 7% over the 500 and 17% over the 250 pound super applications. Increasing the super application from 1000 to 2000 pounds increased the phosphorus content of the hay by 7% but did not increase the yield. Red top, bent grasses, and weeds were replacing the timothy in the 250 pound super plot by the second cutting of the second harvest year. This shows that on this soil the phosphorus supplied in 250 pounds of superphosphate was inadequate for timothy for more than a two year period.

The combination of 1000 pounds of rock phosphate with 50 pounds sulfur and 500 pounds super produced 12% more timothy hay than 500 pounds of super alone. Timothy yields and phosphorus content from 2000 pounds of rock phosphate compared favorably with those from 1000 pounds super. The addition of 456 pounds of sulfur with 2000 pounds of rock phosphate increased the phosphorus uptake by timothy hay by 8 per cent.

Yields and phosphorus content of alfalfa and Ladino-brome (Table 11) produced by 2000 pounds of rock phosphate compare favorably with those of 1000 pounds of super and also the combination of 500 plus 1000 pounds of rock phosphate and 50 pounds of sulfur. Alfalfa,

Ladino-brome, and timothy have removed 27, 30, and 32 per cent respectively of the 200 pounds P_2O_5 applied as 1000 pounds 20% super. These are high uptake percentages. We are anticipating a change in the relative performance of the rock vs. super during the next 2-3 years.

One cannot make recommendations from two years data with only one location. However, we believe these results indicate that finely ground raw rock phosphate may have an important place in our forage program. In 1951, two additional experiments of this type were laid out, one on Merrimac fine sandy loam and the other on a heavy soil, Hudson silt loam. Treatments include 0 phosphorus, 0 phosphorus with 100 pounds sulfur; 500,100, and 2000 pounds 20% super; 1000 rock, 1000 rock + 100 sulfur; 2000 rock + 100 sulfur; and 4000 rock + 100 sulfur.

Table 10. Sources of Phosphorus: Super vs. Rock Phosphate

Summary 1950 and 1951 Yields and Phosphorus Content

Timothy

	20% Super 250 lbs.			20% Super 500 lbs.		
	Yield	%P	lbs. P	Yield	%P	lbs. P
1950	7570	.154	11.658	8512	.156	13.237
1951	8460	.142	11.988	9108	.142	12.947
Total	16030	.148	23.65	17620	.149	26.18

	20% Super 1000 lbs.			20% Super 2000 lbs.		
	Yield	%P	lbs. P	Yield	%P	lbs. P
1950	8529	.158	13.51	8469	.169	14.31
1951	10255	.142	14.49	10477	.149	15.66
Total	18784	.149	28.00	18946	.159	29.97

	2000 lbs. Rock P No Sulfur			2000 lbs. Rock P 100 lbs. Sulfur		
	Yield	%P	lbs. P	Yield	%P	lbs. P
1950	8041	.151	12.16	8176	.156	12.72
1951	10343	.134	13.90	9729	.138	13.45
Total	18384	.142	26.06	17905	.146	26.17

	2000 lbs. Rock P 456 lbs. Sulfur					
	Yield	%P	lbs. P			
1950	8180	.165	13.50	8496	.174	14.42
1951	10805	.139	15.05	10620	.147	15.63
Total	18985	.148	28.05	19116	.160	30.05

	4000 lbs. Rock P 100 lbs. Sulfur			1000 lbs. Rock P + 50 lbs. Sulfur 500 lbs. 20% Super			
	Yield	%P	lbs. P	Yield	%P	lbs. P	
1950	8804	.162	14.27	8801	.155	15.41	
1951	10580	.144	15.26	10874	.142	13.60	pH 6.5-6.7
Total	19384	.152	29.53	19675	.148	29.01	

"Average of 4 replicates - pounds per acre, 15% moisture
Brown Farm, Amherst, Mass.

Table 11. Sources of Phosphorus: Super vs. Rock Phosphate

Summary 1950 and 1951 Yields and Phosphorus Content
Ladino-Brome

	20% Super 1000 lbs.			20% Super 2000 lbs.		
	Yield*	%P	lbs. P	Yield	%P	lbs. P
1950	6468	.278	18.00	6782	.290	19.68
1951	3220	.256	8.25	3436	.265	9.12
Total	9688	.271	26.25	10218	.282	28.80

	No Sulfur 2000 lbs. Rock P			100 lbs. Sulfur 2000 lbs. Rock P		
1950	6182	.277	17.12	6526	.275	17.94
1951	3275	.249	8.14	3224	.255	8.21
Total	9457	.267	25.26	9750	.268	26.15

Alfalfa

	20% Super 1000 lbs.			20% Super 2000 lbs.		
1950	4311	.210	9.07	4584	.204	9.29
1951	7572	.194	14.68	7611	.194	14.72
Total	11883	.200	23.75	12195	.197	24.01
	No sulfur 2000 lbs. Rock P			100 lbs. sulfur 2000 lbs. Rock P		
1950	4679	.190	8.90	4454	.198	8.83
1951	7772	.181	14.03	7122	.183	13.01
Total	12451	.184	22.93	11576	.189	21.84

Ladino-Brome

	456 lbs. Sulfur 2000 lbs. Rock P			100 lbs. Sulfur 3000 lbs. Rock P		
	Yield	%P	lbs. P	Yield	%P	lbs. P
1950	6315	.286	18.08	6510	.293	19.07
1951	2969	.251	7.46	3074	.249	7.64
Total	9284	.275	25.54	9584	.279	26.71
	100 lbs. Sulfur 4000 lbs. Rock P			500 lbs. Super 1000 lbs. Rock P + 50 lbs. Sulfur		
1950	6534	.294	19.20	6490	.285	18.49
1951	3155	.258	8.15	3258	.258	8.40
Total	9689	.282	27.35	9748	.276	26.89

*Average of 4 replicates - pounds per acre, 15% moisture
Brown Farm, Amherst, Mass.

Alfalfa

	456 lbs. Sulfur 2000 lbs. Rock P			100 lbs. Sulfur 3000 lbs. Rock P		
	Yield	%P	lbs. P.	Yield	%P	lbs. P
1950	3949	.211	8.33	4051	.198	8.05
1951	7752	.194	15.05	7915	.177	13.99
Total	11701	.200	23.38	11966	.184	22.04
	100 lbs. Sulfur 4000 lbs. Rock P			500 lbs. Super 1000 lbs. Rock P + 50 lbs. Sulfur		
1950	5150	.205	10.08	4371	.193	8.43
1951	7791	.183	14.45	7789	.179	13.98
Total	12941	.188	24.53	12160	.184	22.41

pH 6.5 - 6.7

New Hampshire Agricultural
Experiment Station

Title: Ladino Clover and Trefoil Variety Trials

Leaders: F. S. Prince, L. J. Higgins, P. T. Blood and G. M. Dunn

Three replications of seven California and Oregon strains and varieties were seeded in August 1949. Breeders Ladino and Commercial Ladino, also, were included in this trial.

Four harvests were made in 1951. There was no significant difference in yield between the varieties tested; highest yields were obtained with Breeders Ladino.

Nine trefoil strains were seeded, also, at this time in a cooperative test with Cornell University.

Two harvests were made in 1951. Strain differences were non-significant.

Title: Alfalfa Variety Trial

Leaders: F. S. Prince, L. J. Higgins, P. T. Blood and G. M. Dunn

This test was seeded in August 1950, and consisted of five replications of the following: Ranger, Buffalo, Narragansett, Grimm, Ontario, Atlantic, New Hampshire Brome, and New Hampshire Brome with Ranger.

Two harvests were made in 1951. The yield of Grimm was very much reduced because of failure to obtain a good stand. Mean yields of Ranger, Buffalo, Ontario and Atlantic were not significantly different, although the yield of Ranger was slightly greater than that of the other three varieties.

The yield of Narragansett alfalfa was outstanding, exceeding that of the next best one, Ranger, by 44%. Narragansett also yielded about 90% more than the combination New Hampshire Brome plus Ranger.

Title: Bromegrass Variety and Polycross Progeny Trials

Leaders: F. S. Prince, L. J. Higgins, P. T. Blood and G. M. Dunn

These experiments are part of a NE-10 project, supervised by Dr. R. P. Murphy of Cornell University.

The variety trial consisted of six New York brome synthetics plus the two checks, Lincoln and Canadian Commercial. Six replications were seeded in August 1950, three of them alone and three with Ranger Alfalfa.

Yield data were taken at two harvests in 1951. One of the New York synthetics exceeded the yield of the better check variety, Lincoln, by about 400 pounds dry matter per acre. Yield data will be taken in 1952.

Seeding was also made in August 1950 of polycross seed progenies of 25 selected clones, obtained from Dr. Murphy. These polycross progenies were seeded alone in 4 replications, with the two checks, Lincoln and Canadian Commercial.

Several of the synthetics outyielded the better check, Lincoln. Yield data will again be taken in 1952.

Leaf spot infection was severe in 1951 on both the synthetics and the polycross progenies. Brown leaf spot, caused by Pyrenophora bromi was predominant, although it appeared that Selenophoma bromigena was also present. Infection was noticeably lighter in the brome-alfalfa plots. Two ratings were made in the field for leaf spot in the fall of 1951. None of the synthetics or polycross progenies showed good resistance, although some were considerably more resistant than others. Clones of some of this material were brought into the greenhouse in October 1951. These plants will be selfed, the seed thus obtained grown in the greenhouse in the spring of 1952, and artificial inoculations made in an attempt to isolate resistance to these two diseases.

Title: The Influence of Soil Type on the Persistence of Perennial Legumes

Leaders: Louis T. Kardos and Paul T. Blood

Seedings of four perennial legumes which were made in the dry year of 1950 were harvested in 1951 as two cuttings of hay. The seedings were located on three soil types: 1. Stratham gravelly loam, a droughty Brown Podzolic soil located in southern New Hampshire; 2. Paxton loam, a Brown Podzolic soil in southern New Hampshire; 3. Worthington loam, a Podzol in northern New Hampshire. Both of the latter soils have good water-holding capacities.

The yield results on the Stratham gravelly loam indicated that alfalfa persisted best under conditions of drought with birdsfoot trefoil second. Perennial red clover and Ladino clover were almost total failures.

On the Paxton loam Ladino clover persisted best with alfalfa and red clover next and about equally good and trefoil poorest. At the second cutting the alfalfa showed severe potash deficiency symptoms, the Ladino mild symptoms, and the trefoil and red clover no potash deficiency.

On the Worthington loam none of the legumes persisted to any appreciable degree, although the timothy which was seeded in association with the legumes grew very well. The August 1950 seeding which was made on this site went into the winter with insufficient growth to overwinter the legumes adequately. This area will be reseeded in 1952 in an attempt to secure a more adequate initial stand.

Title: The Fertility Needs of Ladino Clover

Leaders: Louis T. Kardos and Ford S. Prince

Field plots were established on a Paxton loam soil in southern New Hampshire and on a Worthington loam in northern New Hampshire. The treatments were designed to study the interaction of lime and potash variables on the yield of Ladino clover. Lime was applied at 0, 1 and 2 tons per acre, and the potash (K_2O) treatments were at 0, 25, 50 and 100 pounds per acre with one of the 100-pound series split into two equal parts, half being applied in early spring, the remainder after the first cutting.

All plots received a uniform initial application of 25 pounds of N and 200 pounds of P_2O_5 per acre before seeding. Each treatment was replicated three times.

In both locations the Ladino clover responded to the applications of lime at all potash levels. In the Worthington soil, for which the initial pH was 4.90, where no potash was applied, the 2-L application increased the Ladino yield in the second cutting by 144% and where 100 pounds of K_2O were applied the yield increase from the 2-L treatment was about 20%. On the Paxton soil the respective increases were 130% and 68%.

The response from potash applications on the Worthington soil were even more remarkable than from lime. Where no lime was applied the yield increment from 100 pounds of K_2O was 180% and on the 2-L plots the yield increment 100 pounds of K_2O was 70%.

Where lime was inadequate there was a tendency for the single application of 100 pounds of K_2O to be slightly better than the split application (50 pounds in the spring and 50 pounds after the first cutting). At the 2-L level of liming there was no difference between these treatments.

Title: The Influence of Pasture Irrigation under New Hampshire Conditions

Leaders: F. S. Prince, P. T. Blood, L. T. Kardos, K. S. Morrow and B. P. Rines

The growing season in New Hampshire during 1951 was ideal. Rainfall was not only ample for pasture production, but the rains were well and evenly distributed throughout the season. For that reason, the irrigation equipment available for this experiment was never set up.

Since the experiment in 1950 was set up in a newly seeded field, and as there appeared to be considerable difference in the stand that was established with respect to species, cages were set on the various areas in 1951 to determine differences in yield on the plots which were irrigated and non-irrigated in 1950.

One harvest only toward the end of the pasture season was taken from these cages. Actually there was only a slight difference between the percentages of red and Ladino clovers in the plots. Of more significance perhaps was the greater percentage of grasses in the non-irrigated than in the irrigated areas. These data follow:

	% Ladino	% Red Clover	% Grass
Irrigated	11.9	38.4	49.7
Non-irrigated	9.6	33.7	56.7

Observations on the total area indicated that the moisture holding capacity of the soil had more influence on the type of stand that came through the second season than irrigation, and that even with the severe drought experienced in 1950, (the year of seeding) none of the area had to be reseeded.

Title: The Relationship between the Diet of Dairy Animals, the Digestibility and Utilization of Protein and Energy, the Synthesis of Some of the B Vitamins and the Activity of the Flora of the Digestive Tract

Leaders: N. F. Colovos, H. A. Keener, A. E. Teeri and H. A. Davis

The effort to find how various factors affect the digestibility and utilization of various forages by dairy cattle is being continued. The work during the present year has to do with the nutritive evaluation of forages preserved by different methods. In one study the relative value of comparable forage preserved by mow curing, field curing and ensiling with molasses is being determined for the third year. In another study the value of sulphur dioxide as a preservative is being determined for the second year.

Last year in an attempt to find the cause of the lower digestibilities of the protein and the energy of the silage as compared to the digestibilities of the protein and energy of the field-cured and mow-cured hays, pulverized limestone was fed with the silage in order to neutralize the acidity of the silage. The addition of the limestone caused a further depression in the digestibility in all the silages studied. Because of the possibility that the customary inclusion of relatively large amounts of pulverized limestone in the dairy ration may have important digestion depressing effects, this work is being continued on an expanded scale.

Title: Maximum Use of Roughage in Feeding Dairy Cattle

Leaders: H. A. Keener, N. F. Colovos and H. A. Davis

The work to determine the relative advantages of field curing, field curing and ensiling forage crops is being continued. The work this year includes studies on losses during harvesting as well as losses in the mow and in the silo. Feeding studies are also being conducted with dairy heifers in order to determine the relative value of the different forages for growth. As in two previous years considerably better gains are being made by those animals which are being fed grass silage.

For the second year the value of sulphur dioxide as a silage preservative is being studied. This work includes studies on the preserving action of the sulphur dioxide, palatability and growth studies with dairy heifers and a study of the nutritional value of the additional sulphur consumed by animals fed such silage. To date the results with sulphur dioxide appear rather satisfactory. Several important questions concerning the effects of the rather high sulphur on the animal, however, remain unanswered.

The work on the trench type silo started last year has been continued. This year a shallow trench type silo was dug at a total cost of approximately $9.00. An above ground trency-type silo also was constructed with rough lumber and fence posts. This type of structure appears to have possibilities for use where the water table is close to the surface or where a trench cannot be dug because of ledge. The amount of spoilage in almost all trench silos in this region is very heavy this year because of heavy rainfall.

Title: The Effect of the Maximum Use of Roughage upon the Reproductive Efficiency of Dairy Cattle

Leaders: H. A. Keener, K. S. Morrow, F. E. Allen and G. P. Percival with the cooperation of K. C. Beeson, U. S. Plant, Soil and Nutrition Laboratory, Ithaca, New York

This study is an attempt to determine the effect of intensive fertilization and liming on the minor element content of certain forage plants and also the effects of such forage on the growth, production and reproduction of dairy cattle when it is fed as the principal part of the ration.

Ladino clover-brome grass mixtures and timothy are being grown under these experimental conditions. The copper content of all species has been depressed to very low levels. The same is generally true for cobalt and iron, but the levels of these elements is not quite as low in the Ladino clover as in the grasses. There is no consistent effect with respect to manganese.

Dairy heifers on the experiment are fed either the heavily fertilized Ladino-brome hay and degermed corn meal or the heavily

fertilized timothy hay and degerned corn meal supplemented with urea to equalize the protein content of the ration. While the Ladino-brome fed animals have maintained a normal weight on the average, the timothy fed animals were nearly 20% underweight at both 12 and 18 months of age. Contrary to what might be expected, the timothy fed animals have conceived exceptionally well to date, but the conception rate of the Ladino-brome fed animals is very low. Further data is needed before definite conclusions can be drawn on this observation.

Title: Supplemental Vitamin D for Dairy Cows

Leader: H. A. Keener

This project has been concerned the last four years with a study of the vitamin D content of forage as affected by species, stage of maturity, season of year, environmental conditions, and method of harvesting and storage. The experimental work has been completed and the results are being prepared for publication.

It would appear that in general the provitamin D content of early cut and first cutting forage is considerably lower than that of late cut and second cutting forage, and that the provitamin D content of legumes is generally higher than that of the grasses.

New Jersey Agricultural Experiment Station

Title: Pasture Renovation Studies

Leader: M. A. Sprague

Studies were continued with emphasis placed on preparation of grass sods prior to cultivation and with a view to doing a better job of killing the sods to reduce competition with new seedlings. Chemicals were employed to reduce the amount of cultivation required and the size equipment to do the job was consistent with those found on the small family farm. All treatments were compared with conventional methods of renovation involving heavy disking of untreated sods.

A low rate of TCA per acre was used to kill the old close-grazed bluegrass sods; and heavy and light diskings plus no disking treatments were applied 30 days after spraying. Seeding immediately followed the disking during the last week of August. Seasonal yields from such renovations established in 1949 and 1950 plus observations from six newly established renovations (1951) are encouraging with respect to the merit of this method for seedling orchard grass, Ladino clover, alfalfa, bromegrass and birdsfoot trefoil.

Two diskings of the chemically treated sod produced an excellent seedbed and essentially the same degree of establishment and yield

as the live sod disked seven times or more. In one experiment excellent establishment was obtained by seeding directly on the killed sod without cultivation, but with rolling once with the cultipacker roller after seeding. Botanical composition of the harvested forage indicated that almost 100 per cent of the forage in the plots where the sod was killed before renovation was of the seeded species, whereas plots not chemically treated contained large amounts of bluegrass, white clover and weeds to the detriment of the growth of the new seeding. On heavy disked, unsprayed (conventional) renovated plots the harvested forage one year after renovation consisted of 11 per cent Kentucky bluegrass. This amount of so aggressive a species would be expected under conditions of high fertility and heavy grazing to become far more prevalent and competitive in years to come.

Many conditions determine the amount per acre of chemical to be used and the time interval required after spraying before seeding can be attempted. Variations in season, climate and soil type would alter these requirements. Tests are underway at the present time in New Jersey to establish the effect of these conditions. The amount of chemical to be used must be high enough to kill the regenerative parts of the perennial grasses at the season of application yet low enough to insure its disappearance from the particular soil prior to reseeding.

Title: Winterkilling Studies with Ladino Clover

Leader: M. A. Sprague

Laboratory freezing studies with field grown and cold hardened plant material showed that when the rate of lowering of the temperature, when freezing stolons, is slow little damage is inflicted compared with rapid lowering of temperatures. Observations in the field of temperature changes in and above Ladino foliage indicated a much slower change of temperature at the stolon level where a good top growth is present than where absent. These phenomenon may explain in part the beneficial effects of grasses in association with legumes as an aid in bringing the clovers safely through the winter period.

Table 12. Recovery growth of Ladino clover stolons during 25 days in the greenhouse following cold treatments with different rates of cooling

Temperature Treatments	Time in Freezer	Dry Weight Clone 3	Recovery Growth Clone 5
Degrees F.	Hrs.	Gms.	Gms.
36 to 10	13	0.53	0.66
30 to 10	10	.73	.68
25 to 10	7.5	.37	.55
20 to 10	5	.05	.31
15 to 10	2.5	.00	.08
36 to 8	14	.59	.76
Unfrozen	0	1.06	.88

Title: Ladino Clover Strain Tests

Leader: M. A. Sprague

Nineteen strains of Ladino clover from the major seed producing areas in the United States and from Italy were under observation at New Brunswick for the second year. (1950 Annual Report, page 55).

Title: Small Grains for Fall and Spring Pasture

Leader: M. A. Sprague

Four years' data from this experiment (1947 Annual Report, page 54) were summarized as the effects of 3 grazing systems on forage and grain yields from rye, wheat and oats compared with no grazing.

Table 13. Four year average yields of wheat, rye and oats* harvested as pasture at New Brunswick, New Jersey (1947-1951).

	Yield of dry forage per acre					
	Wheat		Rye		Oats	
Grazing Season	lbs.	%	lbs.	%	lbs.	%
Fall only	763	39.9	1034	34.0	514	54.6
Spring only	1656	86.7	2618	86.0	750	79.7
Spring after fall	1148	60.1	2009	66.0	427	45.4
L.S.D. 1% = 187 lbs.						
Fall plus Spring	1911	100.0	3043	100.0	941	100.0

*Three years data in the case of oats.

Table 14. Four year average yield of grain from Thorne wheat, Balbo rye, and Wintok oats* given several grazing treatments (New Brunswick, New Jersey 1947-1951)

	Average yield of grain per acre					
	Wheat		Rye		Oats	
Grazing Season	bu.	%	bu.	%	bu.	%
None	27.1	100.0	28.5	100	44.7	100
Fall	31.9	118.7	31.5	111	50.5	113
Spring	18.9	70.0	20.9	73	45.1	101
Both	23.3	86.0	21.7	76	53.3	119
L.S.D. 5% = 2.7 bu.; 1% = 3.6 bu.						

*Three years data in the case of oats.

The same conclusions were evident as were observed after 3 years' trial (1950 Annual Report, page 57). The most forage per acre was obtained from grazing in both fall and spring. Fall grazing increased the yield of grain over no grazing but spring grazing reduced the subsequent grain yields. The total yields of TDN per acre were greatest when grazed both fall and spring and was over twice the yield of not grazed plots. All grains reacted essentially the same to the grazing treatments.

In other experiments with rye on Penn soil 40 lbs. of nitrogen fertilizer applied in the fall after grazing was completed increased spring forage yields 239 per cent whereas the same amount of nitrogen added in February increased yields 249 per cent. Silage yields following spring grazing were 1.5 T and 4.5 T per acre respectively. No advantage in pasture yields were observed by including vetch in the seeding mixture, but yields of green material for silage in May were increased almost 400 per cent with the vetch.

Title: Time of Fertilization Study with Pastures

Leader: E. R. Purvis

The attached tables contain the results for the second year of a study to determine the influence of time of application of fertilizer upon pasture yield.

All fertilized plots received a 5-10-10 fertilizer at the rate of 750 pounds per acre. Dates of application are shown in table.

These data indicate the drastic effects of drouth upon yield on Farm 2, where no forage was produced after the middle of June. Time of fertilization made no significant difference in total yield at either location. The period of peak yields was extended when the fertilizer was applied after the first harvest in May.

Time of Fertilization Study with Pastures
(Results from 2nd year of study)

Table 15. Farm 1 -- F. W. Fuchs, Belvidere, N. J.
Soil Type -- Chenango Silt Loam

Ladino Clover and Orchard Grass
Summary Data for 4 Harvests in 1951

Treatment	Yield in lbs. dry wt. per acre				
	Date of Harvest				
	5/10	6/18	8/2	9/20	Total Yield
No fertilizer	1849	1644	1830	2034	7357
Fertilized in Nov.	2857	1704	2085	2089	8735
Fertilized in March	2784	1988	2299	2167	9238
Fertilized in May	1982	2511	2099	2099	8691

Table 16. Farm 2 -- Fred Frohn, Medford, N.J.
Soil Type -- Collington Sandy Loam

Ladino clover, Timothy, and Bluegrass

Treatment	Yield in lbs. dry wt. per acre				
	Date of Harvest				
	5/15	6/19	*	*	Total Yield
No fertilizer	2012	1371			3383
Fertilized in Nov.	2307	1169			3476
Fertilized in March	2323	1062			3385
Fertilized in May	1826	1976			3802

*No 3rd or 4th harvest because of drouth.

Title: Forage Crops Investigations

Leaders: H. Douglass Gross and G. H. Ahlgren

The alfalfa variety-fertilizer test cited in the 14th Annual Report (p. 56) is now in its fifth harvest year. This test involves the use of Atlantic, Buffalo, Ranger and Kansas Common alfalfas under the following 12 fertilizer treatments:

0-50-50 + B*	50-200-200 + B	0-200-50 + B
0-100-100 + B	100-200-200 + B	0-200-100 + B
0-200-200 + B	0-50-200 + B	0-200-200
25-200-200 + B	0-100-200 + B	100-200-200

*Borax added at 50#/A.

An analysis of the yield data for the five years (nine cuttings) indicate that:

1. There is no significant differential response of the varieties to the fertilizer treatments used,
2. the variety averages differ between treatments, and
3. the variety yield averages for all treatments differ significantly.

The varietal differences are in line with long-term variety tests in New Jersey. Atlantic was significantly higher yielding than the other three varieties used, and Kansas Common yielded significantly more than did Buffalo or Ranger. The yields for the varieties were: Atlantic 2.80 tons/A, Kansas Common 2.52 tons/A, Buffalo 2.54 tons/A and Ranger 2.52 tons/A (L.S.D. .05 0.11 tons/A).

The treatment differences further confirm the conclusion that potash is essential to long-lived, high-yielding alfalfa stands. With but one exception (0-200-100 + B), the high yielding treatments contained 200#/A/yr. K_2O. The two treatments which had this high increment of potash but which did not yield well contained low (25#/A/yr.) and medium (50#/A/yr.) nitrogen components. The stand estimates parallel the yield data in this respect, i.e. those treatments which were high in potash gave high percentages of alfalfa, excepting where low or medium nitrogen was included.

From the yield data obtained, it is apparent that neither phosphorus nor boron were critical elements in the treatments.

The "between years" term was the only other significant factor in the analysis. That yields should differ from year to year is to be expected in a perennial crop like alfalfa.

That the varieties used do not require differential fertilization is certainly encouraging as regards practical alfalfa production in New Jersey.

Title: Time of Cutting Studies with Grass Silage Crops

Leaders: Claude Eby and M. A. Sprague

Seedings were made at Beemerville, New Jersey during the spring of 1950. Replicated plots were of all combinations of two legumes, Ladino clover and birdsfoot trefoil, with 3 grasses reed canary grass, orchard grass and bromegrass. The plots were large enough to facilitate the use of a Fox chopper to harvest the forage. Harvests were begun in the spring of 1951 and first harvests were planned to coincide with the blossoming date of the 3 grasses. Harvests of the first crop were made May 24, June 18 and June 28, 1951 on each of the mixtures. A second crop was taken in July and August.

Yield and persistency of stand of the several mixtures under the 3 harvesting times are of particular interest on this well fertilized land. Of particular interest during the first year of establishment was the effect of the rapid growing Ladino clover on the establishment of the grasses associated with it. Orchard grass, a rapid starter, established itself well with Ladino. However, bromegrass and canary grass sown with Ladino clover resulted in a very thin stand (approximately 10 per cent of 1st year's forage) whereas where these same 2 grasses were sown with the slow starting trefoil they spread vigorously and made up over 85 per cent of the forage produced. An average of 16.6 tons per acre of green material was harvested from the Ladino plots and 15.5 tons from the plots including trefoil during 1951. Average yield of all bromegrass plots was 15.5 tons per acre, reed canary grass 17.3 tons and orchard grass 17.1 tons. Some volunteer red clover was found in all plots.

Title: Utilization of Pasture in the Production of Beef

Leader: George Vander Noot and M. A. Sprague

This project (Annual Report 1949, page 66; 1950, page 56) was continued a third season and showed results exceptionally consistent with previous years. During 1951, 14 Angus steers averaging 526 pounds were provided only pasture consisting of 21 acres of 5 year old stands of Ladino-orchard grass and Ladino-bromegrass. Grazing started April 16 and continued to October 24, 1951. During the 191 days the average gain per animal was 1.51 pounds per day, a total of 290 pounds. The average production per acre was 193 pounds of beef plus 1.9 tons of grass silage per acre removed the first week of June 1951.

Following pasture the steers (averaging 814 lbs.) were fed cob meal, molasses, soybean meal and mixed hay in a dry lot. During 68 days (January 2, 1952) they had gained 130 pounds per steer, an average daily gain of 1.9 pounds.

60.

Table 17. Steer gains on pasture

	1949	1950	1951	Average
Acres pastured	21	21	21	21
Animals pastured	20	16	14	16.7
Days pastured	186	168	191	182
Animal gain per day	1.4 lbs.	1.62 lbs.	1.51 lbs.	1.51 lbs.
Animal gain per season	260 lbs.	273 lbs.	290 lbs.	274 lbs.
Total gain per acre	226 lbs.	198 lbs.	193 lbs.	206 lbs.
Grass silage yield per acre	4.0 T.	3.9 T.	1.9 T.	3.3 T.

Title: Grassland Insect Investigations

Leader: R. S. Filmer

Problem 1. Search for control measure that will give adequate control of forage insects without leaving harmful residues on the harvested crops.

Problem 2. Study the distribution and abundance of insects attacking forage crops and determine type of injury and measure its importance on quality and quantity of forage.

Problem 3. Study role of root feeding insects and the prevalence of crown root rot, Sclerotinia trifoliorum in red clover plantings.

Problem 4. Study life history of pea aphid to determine the possibilities of predicting the seriousness of pea aphid outbreaks in central and southern New Jersey.

Problem 5. Ecological studies of the potato leafhopper with reference to preferred food plants.

Results:

Problem 1. Residue studies have been reported in a series of papers by Ginsburg, Filmer and Reed in the Journal of Economic Entomology. New insecticides are tested as they become available.

Problem 2. Pea aphid outbreaks are restricted to alfalfa in south and central New Jersey. Infestations range from 1,000 to 5,000 aphids per sweep. Green weight forage yields were reduced 30 to 60 per cent, carotine content reduced 9 fold. Recommended control measures are a single application of 1% parathion or 1% lindane dust at 40 pounds per acre.

Spittle bug infestations are severe on red clover, moderate to severe on alfalfa. Populations range from 30 to several hundred nymphs per square foot. Excellent control was obtained with 1/4 pound of lindane or 1 pound of toxaphene per acre. Green weight forage yields increased from 30 to 89 per cent.

Potato leafhopper, primarily a pest on 2nd and 3rd cutting of alfalfa, has not been serious during 1950 or 1951.

Cornell University (New York) Agricultural Experiment Station

Title: Breeding and cytogenetic investigations with the forage plants of New York. (B-J Plant Breeding Project 76)

Leaders: R. P. Murphy, S. S. Atwood and D. L. Smith

(This report covers the fiscal year 1950-51.) The breeding and cytogenetic studies are described here separately for each species.

A. Alfalfa

1. 1946, 1947, 1948, 1949, 1950 Uniform Observational Nurseries.

Yields were obtained from all these row nurseries except the one planted in 1950 which will be harvested in 1951. The progeny from several clones have appeared outstanding and these clones will be used in further studies.

2. 1948, 1949, and 1950 Clonal Nurseries. The clones in these nurseries were noted for several characteristics and the more promising ones will be maintained and progeny tested. The 1948 nursery will probably be discarded in 1951 after the selected clones are transferred to the maintenance nursery.

3. 1949 Single Cross and Inbred Nurseries. These progenies were studied intensively. From these data several "double-cross" hybrids and the advanced generations of several single crosses will be produced and tested as experimental varieties.

4. 1950 Single Cross and Inbred Nursery. This material became well established in 1950 and includes crosses of the best clones with rhizomophorous and creeping-rooted selections.

5. Genetic Studies, Bacterial Wilt Resistance, Leaf Spot Resistance and Other Characters. These studies are being continued, in many cases by graduate assistants, and will be source material for new clones with disease resistance.

6. Insect Reaction Tests. This work is in cooperation with Professor G. G. Gyrisco of the Department of Entomology. A number of clones were tested for their reaction to the potato leaf hopper.

B. Red Clover

The seed harvested from plants from ten sources which had survived for two harvest years was planted in 1950 and good stands were obtained. This cycle of selection will be continued and seed will be harvested from surviving plants in 1952.

C. Ladino Clover

No work on this crop was done in 1950. Efforts to establish a source nursery of seedlings failed.

D. Zig-Zag Clover

The ten clones previously worked with are being maintained.

E. Alfalfa, Clover and Grass Introduction Nursery

The following materials were established in short rows for observational purposes:

(1) 76 collections of alfalfa from foreign plant introductions,
(2) 9 collections of alfalfa " other sources,
(3) 46 collections of clover " several sources,
(4) 16 collections of bromegrass " foreign plant introductions,
(5) 10 collections of Bromus sp. " " " " ,
(6) 28 collections of Phalaris sp. " " " " ,and
(7) 4 collections of Phleum sp. " " " " .

F. Clover and Trefoil Interspecific Hybridization

Efforts are being made to intercross certain species within both of these crops. It is too early to learn if any crosses have been successful.

G. Bromegrass

1. 1947 Polycross Seed Production Nurseries I and II. These nurseries were discarded in 1950 after the selected clones which are being progeny tested had been transferred to the maintenance nursery.
2. 1948 Polycross Seed Production Nursery. Polycross seed was harvested in 1950 from 28 out of 240 clones. These clones were transferred to the maintenance nursery and this nursery has been discarded.
3. 1948 Inbred and Single Cross Nurseries. The plants in these spaced-plant nurseries were noted again in 1950 and 268 plants were selected for a polycross seed production nursery.
4. 1948 Breeding Studies. Mr. C. C. Lowe, a graduate assistant, made further observations in 1950 on the variation in time of flowering in relation to seed production for a number of clones. Mr. C. N. Hittle, a graduate student, completed a study on the variation in performance among the progeny from ten open-pollinated heads selected at random from each of 20 clones in a polycross seed production nursery. The results indicated that in order for a clone to have been pollinated by as random a sample of pollen as possible in such a nursery it would be necessary to have it planted in a relatively large number of replications - ten or more. The spaced-plant nursery, used for these studies, was discarded after 201 plants had been selected for a polycross seed production nursery.

H. Orchard Grass

1. 1947 Polycross Seed Production Nursery. This nursery was discarded in 1950 after 108 of the clones selected for progeny testing had been transferred to the maintenance nursery.
2. 1949 Polycross Seed Production Nursery. This nursery was studied in detail in 1950 and seed was harvested from 68 out of 160 clones.

I. Timothy

1. 1948 Polycross Seed Production Nursery. This nursery was discarded in 1950 after the selected clones had been transferred to the maintenance nursery.

J. Reed Canary Grass

1. 1948 Polycross Seed Production Nursery. This nursery was discarded in 1950 after the selected clones had been transferred to the maintenance nursery.

K. Tall Oat Grass

1. 1949 Polycross Seed Production Nursery. This nursery was studied in detail in 1950 and seed was harvested from 64 out of 270 clones.
2. "Awnless" Selection. This material has been maintained and will be incorporated with the material in the 1949 polycross seed production nursery. The seed characteristics of hull-less, awnless and freedom from hairs are desired.

L. 1947 Technic Study and Aftermath Study. These experiments have been completed and the results are still in the process of summarization.

Title: Strain testing and breeding of forage plants for New York State and vicinity, with special emphasis on problems of production during periods of midsummer drought. (Pl. Breed. State Project 9)

Leaders: R. P. Murphy, S. S. Atwood, A. A. Johnson, H. A. MacDonald (Agronomy), C. C. Lowe and R. D. Ensign

(This report covers the fiscal year 1950-51.) The critical evaluation of perennial forage crops varieties depends on the results from a large number of tests made in different locations for a period of years. The results for any one year are important as they contribute to the overall conclusions. A summary of the results of the strain and variety testing to date for each species included is given in the following statement.

During the past five years, extensive tests have been made of the wide range of forage crops varieties and strains. These varieties and strains have included: (1) commercial varieties now in use, (2) new varieties not yet released, and (3) local ecotypes developed through natural selection; and these have been tested against commercial lots commonly available. These tests have been located at Ithaca, Churchville (Monroe County), and Tully (Onondaga County) for the most part, and in farmers' fields in eight counties.

Considerable use of the data obtained to date has been made. The results have been the basis for the variety recommendations for forage crops. Although the results have not been published, they have been presented to seedsmen and county agents for their use.

Alfalfa. Ranger, developed by federal and state plant breeders at Lincoln, Nebraska, has been found to be a variety with high resistance to the bacterial wilt disease and with good winter hardiness. Where the wilt disease has caused depletion of stands,

Ranger has persisted much longer than susceptible varieties such as Grimm, northern variegated, and Kansas and Oklahoma common sorts if properly fertilized and managed. Two newer varieties which have great promise for New York State and vicinity, and which are being increased very rapidly in the West, are Narragansett and Atlantic. It seems probable that as soon as sufficient seed of these three varieties is available that they might replace well over half of the varieties which are now being used such as Grimm, northern variegated, and Kansas and Oklahoma common.

Red Clover. Commercial seed from New York and neighboring states and Kenland, a variety developed in Kentucky, had been found to give higher yield on the average than commercial seed from the cornbelt and areas farther West. A farmer lot from Pennsylvania which has recently been named Pennscott appears promising.

Ladino Clover. Certified seed of this crop produced primarily in the far West, has been superior in yield and density of stand to imported lots and to uncertified lots produced in the West and other areas. The repurified lot developed by the Division of Forage Crops and Diseases of the U. S. Department of Agriculture, has performed well in tests to date. The new selection developed by the California Agricultural Experiment Station has been inferior in yield and persistence.

Bromegrass. The varieties which originated in the central part of the United States - Lincoln, Achenbach, Fischer and Elsberry - have been found to be superior to Canadian commercial lots in seedling establishment, yield, and resistance to the brown leaf spot disease. These varieties have been superior whether grown alone or in combination with alfalfa.

Timothy. No varieties have been found that are superior in yield to much of the commercial seed, but some which are later in maturity seem to have an important place in New York. Varieties such as Climax developed by plant breeders at the Dominion Experimental Farm, Ottawa, Canada, are 7 to 10 days later in maturity than most commercial timothy, and they grow well in association with Empire birdsfoot trefoil, a late maturing hay legume. The practical value of such mixtures as Climax timothy and Empire birdsfoot trefoil, which would permit the hay crop to be harvested as late as the first and second week in July, depending on the location in the state, and still be in reasonably good quality, is being investigated not only at the research level but also in cooperation with seedsmen and county agents on approximately 50 farms.

Orchard Grass. No varieties have been found that are superior in yield to much of the commercial seed. The value of varieties which are later in maturity is being investigated further. Even the latest ones reach the mid-bloom stage by the 3rd week in June. However, this characteristic may be of value in permitting the farmer to vary the time at which he could make grass silage. The most promising of the later maturing varieties seems to be Brage, developed in Sweden, but it is doubtful if this variety will be

increased since it is rather susceptible to leaf spots and no suitable source of foundation seed exists in this country. It is hoped that some of the new experimental synthetic varieties of the same or later maturity which are being developed by the Pennsylvania Station and also here will be superior in performance to Brage.

Meadow and Tall Fescue. The varieties of tall fescue (Alta, Kentucky 31 and Suiter's) have not been different among themselves in performance, and as a group have been superior to Meadow Fescue sorts in yield. These species seem to have a very limited use in New York.

Reed Canary Grass. Ioreed seems to be as good as any of the varieties and farmer lots tested. Superior, from Oregon, has winter-killed almost completely in all tests.

Tall Oat Grass. Tualatin, from Oregon, has been about equal to commercial lots in yield and is about three days later in maturity. This variety seems to be the best material for increase as it shatters less than others and, thus, is more suitable for seed production. This species seems to have a very limited use in New York.

Sudan Grass. The Wisconsin selection, which has just been released and named Piper, has been equal to Wheeler and Calapproved #23 in yield and is superior to these in disease resistance and freedom of prussic acid.

Title: The evaluation of forage crops varieties and strains for their use and adaptation in the Northeast. Subproject I: Evaluation of forage crops varieties and breeding materials for New York (R & MA 9b1 and 9b2 Pl. Breed. 26-1.)

Leaders: R. P. Murphy and S. S. Atwood

(This report covers the fiscal year 1950-51). The progeny testing of selected plants and other research conducted under this project will be reported here separately for each species.

A. Alfalfa

1. 1948 Nursery of Eastern (A-226), Northern (A-225) and Rhizomatous (A-224) Synthetics. These tests were described in some detail in the 1949 report. Additional information on the performance of these synthetics and their components was obtained in 1950. It now seems that none of these three synthetics will be of great promise in this State. The Eastern (A-226) synthetic proved to be too susceptible to downy mildew and leaf spot to be of value. The susceptibility appeared to come primarily from one of the parents, C22.

2. 1948 Ranger Increase Study. This study was described in detail in the 1949 report and the information obtained in 1950 was presented as a thesis by Mr. S. P. Kohli, a graduate student. Further information was obtained in 1951. The results indicate that the six increases of Ranger which were eligible for certification were similar in performance among themselves and similar to the breeder's seed of the variety. However, two other increases which were ineligible for certification (one because of outcrossing to California common

and the other because improper seed stocks - seed produced outside the area of adaptation - was used) showed some differences from the certified Ranger. They were not different in yield from pure Ranger, but in the fall they did not "harden-off" as much and thus may be less winter hardy.

3. 1948 New York Polycross Progeny Test. No further notes were taken in 1950 but the nursery is being maintained as a source of new clones after there has been a considerable loss in stand.

4. 1948 Uniform Advanced Nurseries. Two nurseries were planted this year. Yields and notes on several characteristics were taken in 1950.

5. 1949 Uniform Advanced Nursery. The yields and notes on several characteristics were taken in 1950.

6. 1950 Uniform Advanced Nursery. This replicated plot nursery of 49 varieties seeded alone was planted in 1950 and fair stands were obtained.

7. 1950 New York Polycross Progeny Test. A replicated plot nursery of 100 clones was established in 1950 with fair stands.

8. Other Variety Yield Trials. (Plant Breeding State Project 9.)

B. Bromegrass

1. 1948 Polycross Progeny Test. Yields for one hay harvest and two aftermath harvests were obtained as well as notes on disease reaction and other characteristics.

2. 1949 Polycross Progeny Tests. For the three groups of clones in test, yields for one hay harvest and two aftermath harvests were obtained as well as notes on disease reaction and other characteristics.

3. 1948 Isolation Plots of Eight Synthetics. These have been described in some detail in the 1949 and 1950 reports. Poor to fair yields of seed were obtained from these in 1950. Six of these were established in 1950 in isolated plots, planted with the Syn-1 seed of each, in order to produce the Syn-2 seed for each for testing.

4. Other Varietal Yield Trials. (Plant Breeding State Project 9.)

C. Orchard Grass

1. 1950 Polycross Progeny Tests. This was a replanting in 1950 insofar as seed was available (only a very few clones could not be tested) of the 1949 Polycross Progeny Test, which was a failure, and good to excellent stands were obtained.

2. 1949 Isolation Plots of Two Synthetics. Excellent yields of seed were obtained from these in 1950. In the early (A) synthetic one clone was discarded because of low seed set so only five clones remain as parents. In the late (B) synthetic two clones were discarded, one because of low vigor and one because of susceptibility to powdery mildew, so only five clones remain as parents.

3. Other Varietal Yield Trials. (Plant Breeding State Project 9.)

D. Timothy

1. 1950 Polycross Progeny Test. A replicated plot test of 45 clones was established in 1950 with fair to good stands.

2. 1950 Isolation Plots of Three Synthetic Varieties. These were established in 1950 with good stands.

3. Other Varietal Yield Trials. (Plant Breeding State Project 9.)

E. Reed Canary Grass

1. 1950 Polycross Progeny Test. A replicated plot test of 62 clones was established in 1950 with good to excellent stands.
2. 1950 Isolation Plots of Four Synthetic Varieties. These were established in 1950 with good stands.
3. Other Varietal Yield Trials. (Plant Breeding State Project 9.)

F. Maintenance Nursery

This nursery was maintained and expanded in 1950. The selected clones which are being used in the breeding programs are maintained in this nursery.

Title: Some Factors Affecting the Seedling Establishment of Forage Legumes

Leader: H. A. MacDonald

In studies involving various species and varieties of forage crops, differential strength of seedling establishment was found. While this was of little importance under favorable conditions for growth, it became of considerable importance under conditions unfavorable to early growth. Strong recovery following harvest was found to be associated with strong seedling vigor. This was not true in the case of winter hardiness, however.

Protection of the developing seedling where competition was avoided, as where a mulch is used, improved seedling establishment in most cases. In a few locations increased seedling mortality due to pathogenic organisms resulted.

No advantage was found from high rates of seeding. Under such conditions the individual plant unit was weakened and the seedling population greatly reduced during the first year.

The studies under way bear out the important seedling establishment requirements of (a) timely seeding, (b) need for adequate moisture during and immediately following germination, (c) some seed coverage, (d) necessity for adequate early nutrition, particularly phosphorus and nitrogen, (e) limited plant competition, (f) avoidance of soil crusting, and (g) the hazard of insects and disease.

The difficulty of obtaining conditions favoring strong seedling establishment where grassland renovation is resorted to was again shown by the results obtained. Only under conditions of inadequate seedbed preparation were high seeding rates favored.

Defoliation of both forage grasses and legumes in the seedling stage seriously reduced plant size, winter hardiness, and to some extent resultant plant yield. Seed treatment did not show beneficial results under field conditions.

Title: The Effect of Stage of Growth upon the Yield, Nutritional Value and Longevity of the Principal Forage Grasses and Legumes.

Leader: H. A. MacDonald

During the past year the work of this project was confined to the influence of differing management systems upon the yield and survival of several varying strains of birdsfoot trefoil, alfalfa, and white clover.

The results to date indicate differences between some strains and varieties to be as great as between many species in regard to their management requirement. The type of harvest or grazing system best suited to an individual species or variety is closely related to the particular strain, plant form, habit of growth, physiological requirement, and the ecological conditions under which it is placed. In many if not most instances, an intimate knowledge of the plants worked with, and the situation in which they are placed, will indicate the most desirable management requirement to follow.

The results of this investigation are being prepared for publication.

Title: Studies of Birdsfoot trefoil as a Forage Legume in New York

Leader: H. A. MacDonald

The work of this project continued during 1951 with special emphasis being devoted to (1) seedling vigor and establishment, (2) crop management for high yield and persistence, (3) seed setting, and (4) the improvement and increase of varieties for specific adaptation and use.

Little difficulty was experienced in obtaining successful seedling establishment of birdsfoot trefoil under conditions generally favoring initial growth. The relatively slow seedling growth of this legume, however, renders it at a disadvantage under conditions of stress in the early growth stages. Major factors limiting strong seedling establishment were (a) insufficient soil moisture immediately following planting, (b) inadequate soil fertility including poor inoculation and (c) excessive competition during early development. Inoculation and nitrogen fixation was found to be limited in several areas by the inability of the rhizobium to survive and multiply in certain soil conditions. Preliminary study would seem to indicate the possibility of an antibiotic influence.

The management studies on different birdsfoot trefoil types gave results similar to that reported last year. In the seedling stage Viking birdsfoot trefoil was found to be more winter hardy than most European importations under test. Further study is needed.

Studies of bud drop as a cause of low seed set and yield indicated a close relationship with low light intensity, low day temperature, and wet weather at time of initial bud formation and development. The direct relationship is now being investigated. Foundation seed of Viking birdsfoot trefoil, a new variety for hay and rotation pasture use, was distributed in the fall of 1951 for further increase. Other selections are being increased for further trial.

Title: Rate and Date of Applying Nitrogen Fertilizer to Grass Meadows and Pastures

Leaders: W. K. Kennedy, R. Bradfield and E. F. Sullivan

In 1950 and 1951 grass meadows in northern New York were top-dressed at different rates and dates with nitrogen and complete fertilizer. The yield of hay was highest when the nitrogen was applied in April and lowest when the nitrogen was applied the previous summer. Fall applications resulted in intermediate yields of hay. The decline in yield from fall and summer applications was partially offset by extra aftermath grazing at a time when additional pasture is needed. Economical yield increases were consistently obtained from an application of 50 pounds per acre of nitrogen. Frequently an application of 100 pounds per acre of nitrogen resulted in profitable yield increases when compared with 50 pounds per acre of nitrogen.

A comparison between 50 pounds per acre of nitrogen only and 50 pounds per acre of nitrogen in a 1-1-1 fertilizer was made. On the fine textured glacio-marine clays no yield increase was obtained when a complete fertilizer was used instead of nitrogen only. On coarse textured (loam and fine sandy loam) glacial till and alluvial soils an economical yield increase was obtained by using a complete fertilizer rather than nitrogen only. Since the complete fertilizer is approximately twice as expensive as nitrogen alone it is important to determine accurately when nitrogen can be used alone rather than a complete fertilizer.

In 1951 nitrogen alone and in a complete fertilizer was applied to Orchard Grass harvested five times during the growing season to simulate a grazing treatment. The nitrogen was applied as three or four applications during the growing season, May 1, June 1, July 15 and September 1. If the nitrogen was applied only three times, the May 1 application was omitted. Three applications resulted in better yields of forage and better summer production than four applications. The dry matter yields of immature forage were increased 1920 pounds and 3600 by applying 100 and 200 pounds per acre of nitrogen respectively. In this test there was no advantage in using a complete fertilizer instead of nitrogen alone.

Title: The Effect of Herbicides on the Rate of Drying of Forage Crops

Leaders: W. K. Kennedy and R. Bradfield

In 1951 second cutting legume-grass hay was treated with several herbicides prior to and at the time of cutting. Rates and methods of applying the chemicals were also studied. Applying the materials at the time of cutting had little or no effect on the rate of drying of the forage. If the herbicides were applied 24 to 72 hours prior to the cutting of the forage crop, the moisture content of the forage at the time of cutting was decreased from about 75 per cent for untreated forage to 65 per cent for treated forage. However, as the forage approached a moisture content of 25 per cent, the difference between untreated and treated forage became smaller. The difference in the time required for treated and untreated hay to reach a moisture content of 25 per cent was so small that the use of the herbicides tested to speed the field curing of hay does not appear feasible. It was found that the difference in the moisture content of treated and untreated forage was due to the drying of the leaves rather than the stems. This accounts for the small benefit derived by using herbicides, since the time required for curing hay usually is determined by how rapidly the stems will dry. The study was of a preliminary nature and will be continued in 1952.

Title: The Use of Fungicides to Preserve Moist Hay and Grain

Leaders: Agronomy: W. K. Kennedy and R. Bradfield
Animal Husbandry: J. Thomas Reid, George Trimburger, and K. L. Turk

Approximately five tons of first and second cutting alfalfa hays having moisture contents of 30 to 50 per cent were treated with 2, 4, 6-trichlorophenol. Mold growth was prevented at all moisture levels when the chemical was applied at the rates of 5 and 10 pounds per ton but hay having a moisture content of 50 per cent was not satisfactorily preserved. Bacterial action was excessive and*preserved while untreated hay was moldy and dusty. The treated hays were fed to dairy cows. The daily intakes of roughage were good and no off-flavors of the milk detected. Very small concentrations (less than 0.5 ppm.) of phenol were present in the milk. The concentration was much higher in the butter fat than in the skim milk but off-flavors of the cream or butter were not observed. Dry cows did not accumulate trichlorophenol and then release large quantities in the milk. Experiments showed that the first two or three milkings had as much as five ppm. of trichlorophenol in the milk but the concentration rapidly decreased to the level of the milk from other lactating cows.

Other chemicals have been tested to determine their value as hay and grain preservatives. The most effective ones have been the bromo and chloro phenols and benzenes. The exact physical properties of effective fungicides have not been determined but it appears that the chemical must have some volatility but if too volatile it is dissipated before the hay or grain has reached a safe

*the hay heated. Treated hay stored with 40 per cent or less moisture was well

moisture level. If this occurs the development of mold may be delayed but not prevented.

Title: Alfalfa Snout Beetle Investigations

Leaders: George G. Gyrisco, A. A. Muka and C. E. Palm

Several chlorinated hydrocarbon and organophosphorous insecticides were tested in 1951 as sprays, dusts and mists for the control of the adult alfalfa snout beetle. All of the experiments were conducted on field plots of one-eighth acre or larger in size which were replicated in randomized blocks 2 or more times. All applications were made with standard power machinery. Cage tests were also conducted for the control of the larva of the alfalfa snout beetle.

Dieldrin, aldrin, toxaphene, lindane and parathion as dusts applied at the rate of 1 pound of actual toxicant per acre gave nearly perfect kill of the beetles in 2 weeks under the ideal weather conditions that existed during the test period. Lindane gave the quickest kills, but dieldrin seemed to be somewhat superior to lindane over the test period. Although there was little to choose between the materials tested in 1951, the order of overall effectiveness was dieldrin, first, followed closely by aldrin, lindane, parathion and toxaphene.

All of the insecticides except toxaphene used as dusts were applied as sprays of emulsions at the same rate of toxicant per acre with a low volume-low pressure sprayer. Dieldrin again gave the best kills although there was little to choose, on a toxicity basis, between the materials tested. Sprays did not give any speedier kills of the beetles than dusts but were much more pleasant to apply.

Preliminary trials with a jeep-mounted mist blower showed some promise for large scale treatments but poor infestations of the Y-brood of beetles prevented a good evaluation of that machine for treating the alfalfa snout beetle.

In cage tests, BHC, aldrin, dieldrin, heptachlor, toxaphene, dilan and J. H. 269 were used up to a rate of 20 pounds of actual toxicant per acre while parathion, lindane and J. H. 711 were used up to 70 pounds of toxicant per acre for the control of the larva of the alfalfa snout beetle. None of the materials at any of the concentrations gave commercial control of any instar of the larva. These studies are being continued with other materials and using different methods.

Title: Clover Root Borer Studies with Notes on Spittlebug

Leaders: George G. Gyrisco, A. A. Muka and Lemac Hopkins

In order to determine the minimum effective dosages for each of several insecticides as dusts, a series of concentrations of lindane,

aldrin, dieldrin and heptachlor, ranging from 0.25 to 1.25 pounds per acre of actual toxicant were used in 4 experiments in 1951 for the control of the clover root borer, Hylastinus obscurus.

Aldrin, dieldrin and heptachlor all controlled 95 per cent of better of the borers when used at dosages as low as 0.5 pounds per acre. With lindane, at least 0.75 to 1.0 pounds per acre of insecticide were needed to give comparable kills. While 0.25 pounds per acre of each insecticide gave some kill of the clover root borer, such low dosages did not prove satisfactory.

Residue samples taken at harvest revealed no residues that exceeded 0.5 ppm. In most cases the residues were near zero.

In a timing experiment, aldrin, dieldrin, chlordane, benzene hexachloride, and lindane were used as dusts at the rate of 1 pound of actual toxicant per acre. One series of plots were treated in the early fall, another series were treated early the following spring and a third series were treated with half of the dosage being applied in the fall and half in the spring at the peak of borer flight. All materials with all methods of application and timing proved to be satisfactory.

Spittlebug counts made in the various clover root borer plots showed that all materials at all concentrations used for the borer were also highly effective in controlling spittlebug nymphs.

Title: European Chafer Studies

Leaders: R. H. Burrage and George G. Gyrisco

The 1951 European chafer program included investigations in the chemical control of larvae, and the biology of larvae and adults.

Tests were continued with treatments of parathion, aldrin, dieldrin, chlordane, DDT, lindane, benzene hexachloride and heptachlor, in dust and emulsion formulations, to control European chafer larvae in pasture sod. In this respect, dieldrin and aldrin appeared to be the most promising of the insecticides used; each, applied at the rate of 1 pound per acre of actual toxicant, effectively controlled 3 generations of larvae, and an application of 2 pounds per acre of dieldrin produced 100 per cent control of 2 generations of larvae. Dieldrin and parathion exhibited the most rapid toxic action of the insecticides tried, but parathion had the poorest residual action.

Over 3000 square-foot samples of soil were examined for European chafer larvae, in an endeavor to obtain some information on factors affecting larval distribution, and efficient sampling techniques. Larval populations varied within 2500 sq. ft. areas, from 0 to 18 larvae per sq. ft., and the modal value varied from 0 with very

light populations, to between 4 and 5 with moderately heavy populations. No data have yet been obtained which show positive effects of either soil pH or moisture upon the distribution of European chafer larvae in sod.

Approximately 50,000 European chafer beetles were counted and sexed during the 1951 flight season, so that a continuous record, of the sex ratio and intensity of flight of the beetles, was maintained. The ratio of males to females was as high as 16:1 at the beginning of the season, dropped rapidly to about 4:1 a few days later, and then gradually decreased to approximately 1:1 toward the end of the flight season. Numbers of beetles were marked and released on specific dates to determine the frequency and time of occurrence of recurrent flights by individual beetles. Some were observed to make at least 4 flights during the flight season and 1 male beetle was recovered 9 days after it had been marked. Over 33 per cent of the males which were marked were recovered, whereas less than 2 per cent of the female beetles which were marked were recovered.

Data obtained indicated that female beetles prefer as a site for oviposition sod covered with short grass, to that covered with long grass. An average of 2.08 larvae per sq. ft. were recovered from the plots covered with short grass, and an average of 1.8 larvae were recovered from the plots covered with long grass. The difference in the populations was significant.

Title: Preliminary Study of Feeding Insecticide Treated Alfalfa to Dairy Cattle

Leaders: George G. Gyrisco, L. B. Norton, A. A. Muka and Lemac Hopkins

Ten cows were selected from the normal Cornell dairy herd, 5 each of Brown Swiss and Holstein. One of each breed was fed alfalfa which had been treated in the field with one of the following insecticides: aldrin, lindane, DDT and parathion. The field treated hay had insecticide residues averaging 0.1 to 1.5 ppm. After five weeks of feeding, all of the residues on the hay was artificially raised to 2.0 ppm and the cows were fed this level for an additional 2 weeks. At the end of the 7 week period many of the cows were beginning to go dry so the experiment was largely discontinued except for one of the aldrin cows and one of the DDT cows whose level of residue was again raised to 5 ppm, and the cows were fed this level for 10 days. At the end of this time (59 days), all feeding of treated forage was discontinued.

Briefly, the results may be summarized as follows: At no time during the entire feeding period did any of the residues in the milk exceed a level above the normally expected variations in the respective analytical techniques employed.

No off-flavor or odor that could be attributed to any of the insecticides was detected.

None of the cows rejected any of the hay because of any of the treatments it may have possessed.

The health, weight, butterfat and milk production of all the cows showed no abnormal fluctuations during the course of the experiment that could be attributed to the insecticides.

No residues of DDT or aldrin were present in the omental fat when these samples were taken by biopsy from the live cows 5 weeks after the experiment had started. No residue of aldrin was present in the pancreas, kidney, liver, spleen and brain when these organs were examined at the conclusion of the experiment.

Manure samples showed no significant amounts of residue except aldrin which may have been present as a trace.

There was no variation between the breeds of cows in their reaction to the insecticide treated hay.

Title: White Grub Investigations

Leaders: R. H. Burrage and George G. Gyrisco

Tests on the effects of soil insecticide treatments on the taste and odor of strawberries, grown in treated areas for white grub control, were continued in 1951. The insecticides as dusts were cultivated into the surface soil, before the strawberry plants were planted. Treatments of chlordane and parathion, each at 12 pounds per acre, aldrin, dieldrin, and benzene hexachloride each at 4 pounds per acre, and lead arsenate at 250 pounds per acre, gave no undesirable flavors or odors to the first fruit crop of strawberries of the variety Sparkle in the treated plots when sampled fresh in jam form, and as canned fruit. Fruit from the second crop, one year later, was flavor tested as frozen fruit, jam, and canned fruit. It w as found that treatments of benzene hexachloride and of aldrin, each applied at the rate of 4 pounds per acre, gave mild off-flavors to frozen fresh fruit, and canned fruit, respectively. Treatments of chlordane and parathion each at 12 pounds per acre, dieldrin at 4 pounds per acre, and lead arsenate at 250 pounds per acre, gave no undesirable odor or taste to either of 2 successive fruit crops of Sparkle strawberries.

Pennsylvania Agricultural Experiment Station

Title: Effects of Different Stubble Management Practices on Maintenance of Red Clover (1950 Annual Report, pages 74-75)

Leader: J. B. Washko

The experimental procedure for this experiment was modified somewhat from that reported in 1950. Red clover (Pennscott) was seeded alone in the spring of 1950 instead of with timothy in winter wheat.

The wheat straw and stubble treatments were as follows: (1) straw left on, (2) straw scattered, (3) straw removed, (4) small grain, spring fertilized with 400 lbs. per acre of 5-10-10 and straw removed, (5) straw removed, stubble clipped and fertilized with 400 lbs. per acre of 0-20-20 fertilizer, (6) straw removed, stubble clipped and removed and (7) straw removed, stubble clipped and removed and fertilized with 500 lbs. per acre of a 5-15-15 fertilizer. Across these treatments the following mowing schedule was imposed: no mowing, mowing September 1, September 15, and October 1. Clippings were removed except on the October 1 date in which clippings were removed on one-half of the plots and left on the remaining half. Results were measured in terms of hay yields and clover populations.

As in 1950 regardless of subsequent management if the straw is left on unscattered, hay yields are reduced in amounts ranging from .6 tons to 1.1 tons of dry matter per acre the following year. Removal of straw followed by clipping and removal of stubble again was conducive to best hay yields. The results with the fertilization practices used and leaving clippings on over winter versus removal at the last date (October 1) on forage yields were minor and probably without significance.

Title: Evaluating Various Tall Growing Grasses with Different Legumes and with Nitrogen Fertilizer for Pennsylvania

Leaders: J. B. Washko and R. P. Pennington

The following grasses are being grown with Ladino clover, alfalfa and birdsfoot trefoil at 4 locations in the state; smooth bromegrass, orchard grass, timothy, reed canary grass, and tall oatgrass. In addition to the five already mentioned meadow fescue and tall meadow fescue are being evaluated with 100 pounds per acre of nitrogen applied in split applications of 60 and 40 pounds in early spring and after the first harvest respectively.

Generally highest yields were obtained when nitrogen was applied to the grasses alone, second highest when the grasses were grown in association with Ladino, third highest when grown with alfalfa and lowest when grown with birdsfoot trefoil. On a quantitative basis this data indicates that the legumes were not supplying adequate quantities of nitrogen for maximum grass growth. On a qualitative basis, however, as determined by analysis for protein the legume-grass associations were higher in protein indicating a superior feeding value for legume-grass associations as compared to grass alone with nitrogen fertilization.

Title: Forage and Grain Production of Winter Small Grains as Influenced by Fertilization and Management Practices (1950 Annual Report, pages 73-74)

Leaders: J. B. Washko, R. P. Pennington, A. L. Haskins

The work on this project was continued during the 1950-51 small grain growing season. Clipping experiments were established in

Central and Southeastern Pennsylvania to determine the influence of rate and time of nitrogen application and the period of forage removal on forage and grain production. Grazing experiments which were conducted for the first time, were established in Central Pennsylvania to study time of nitrogen applications, time of forage removal, method of seeding (rows vs. cross drilled) and method of forage removal (clipping vs. grazing). One variety of wheat and one variety of barley were used in each of the 1950-1951 experiments.

Results show that:
(1) Small grains seeded 5 to 6 weeks prior to the regular seeding date produced high yields of T.D.N. before the onset of winter.
(2) The value of the fall forage in terms of T.D.N. was substantially more than half of that produced in subsequent grain.
(3) The T.D.N. value of forage alone from plots clipped in both the fall and spring approached that of the grain from unclipped plots.
(4) In some instances grain yields from plots clipped for forage in the fall were greater than from unclipped plots which produced grain only.
(5) The removal of forage in the spring whether or not preceeded by fall forage removal was especially deleterious to subsequent grain yields.
(6) The second fall forage harvest was not particularly harmful to subsequent grain yields.
(7) The action of grazing cattle as a means of removing forage was no more harmful to grain yields than removing the forage by clipping.

With regard to protein content the forage contained as much as 35 per cent crude protein at the first fall harvest. Protein content of the forage declined as the season progressed although in most instances it was above 20 per cent.

The importance of adequate moisture supply is shown by the difference in fall forage production between plots seeded August 18, 1950 and those seeded August 29, 1950. Plots seeded at the earlier date with ample soil moisture produced larger quantities of forage than those established under the droughty conditions of the latter seeding date. A similar relationship existed in the fall of 1951, a season characterized by low rainfall and therefore low fall forage production.

Title: Yields of Various Forage Species under Irrigation

Leaders: R. B. Alderfer, J. B. Washko, H. R. Wakefield

Supplemental water was applied to various legumes and legume-grass combinations when the soil moisture level dropped to (1) the wilting point and to (2) 1/2 field capacity. Check plots which received only natural rainfall were also included in this experiment. Moisture levels were determined at the 5 inch soil level with the gypsum block technique.

Irrigation was not started until August 7, due to difficulties with the experimental irrigation equipment. A total of 2.40 inches was applied to the wilting point plots and 3.00 inches to the plots maintained at 1/2 field capacity in 2 to 3 applications. Rainfall for August and September totaled 4.40 inches which was 2.09 inches below normal.

The influence of added water on forage yields was quite marked in the 1951 dry season as shown in Table 18. These yields represent only the 2nd and 3rd cuttings for alfalfa alone and in mixture and only the 3rd and 4th cuttings for the Kentucky bluegrass and orchard grass combinations. An additional cutting for all species was possible with irrigation.

No significant yield differences were obtained in 1951 under the two fertility levels used in this experiment, namely 400 and 800 lbs. per acre of an 0-20-20 fertilizer.

Table 18. Yields of Forage under Different Irrigation Treatments 8/14/51-9/19/51.

	Yields D.M. Ton/Acre Moisture Levels			% Increase Over Check Moisture Levels	
Species	Check	Wilting Point	1/2 Field Capacity	Wilting Point	1/2 Field Capacity
Kentucky bluegrass and white clover	.17	.15	.27	--	59%
Orchard and Ladino	.47	.57	.59	21%	26%
Brome & Alfalfa	1.05	1.66	1.99	58%	90%
Alfalfa	1.10	1.67	1.86	52%	69%

Title: Establishing Legumes and Legume-grass Associations in Winter Wheat by Different Practices

Leaders: J. B. Washko

Several tillage methods alone and with fertilization have been tried in early spring to determine their value in establishment of forage species in winter wheat. The various treatments used were: (1) surface seeding, (2) harrowing with spike-tooth harrow and seeding, (3) surface soil scarifying with weeder and seeding, (4) same as (2) and (3) but cultipacking following the seeding, (5) fertilizing with 200 lbs. per acre of 0-20-20, scarifying with weeder and cultipacking, (6) same as (5) but using 400 lbs. per acre of a 0-20-20 fertilizer and (7) scarifying soil with grain drill using 200 lbs. per acre of a 0-20-20 fertilizer. The forage species used were; red clover, Ladino clover and birdsfoot trefoil each seeded alone and orchard grass and Ladino clover seeded in association.

The first year's results indicated that scarifying the surface soil to break up the soil crust was highly beneficial to getting better

establishment of all forage species. The use of the mineral fertilizer while beneficial was not outstanding. Cultipacking after soil tillage and seeding did not appear to give better stands than where this operation was omitted.

Title: Renovation of Unproductive Pastures

Leaders: J. B. Washko and A. W. Clyde

Two experiments were initiated in the late summer of 1951, one at State College and the other in the Northcentral part of Pennsylvania to determine (1) how best can the old sod be destroyed to minimize competition to the seeded forage species and (2) the fertilizer practices and seeding mixtures necessary to get such pastures to produce forage in quantity and quality.

The implements used for eradicating the old pasture sod in these experiments are: (1) Moldboard plow, (2) Disk plow, (3) Heavy cutaway disk, (4) Graham-Hoeme plow and (5) the pasture aerifier. T.C.A. was also used in conjunction with light disking of the old sod. The springtooth harrow was used for subsequent operations in working the seedbed. Lime was added to bring the soil pH to 6.5. Three different soil fertilization practices are being used: (1) 500 lbs. per acre of 20 per cent superphosphate, (2) 500 lbs. per acre of a 0-20-20 fertilizer, (3) 500 lbs. per acre of 20 per cent superphosphate and 500 lbs. per acre of a 5-10-10 fertilizer. The superphosphate and 0-20-20 fertilizer were fall applied and worked into the seedbed and the 5-10-10 will be applied at time of seeding. The following grasses will be seeded in the spring and evaluated with birdsfoot trefoil and Ladino clover in these experiments; tall oat, reed canary, brome, orchard and timothy. Establishment of these species will be studied under the various treatments of these experiments and harvests will be made at the silage stage for dry matter determinations.

Title: Trace Element Survey of Pennsylvania

Leaders: Agronomy Department: R. P. Pennington
Animal Nutrition: C. E. French and R. W. Swift

A survey of the trace element content of plants in relation to soils has been started. The project will involve the collection of plant samples from different well drained soils developed from different soil parent materials.

The plants used as indicators will be red clover and timothy which will be sampled at full bloom and head stage respectively. Mature oat grain will also be used.

The plant samples will be analyzed for trace elements in order to get an indication of which soils are low in these elements.

About 600 samples of red clover and timothy have been collected. In each case a soil sample was taken and information as to previous cropping and fertilization was obtained.

These plant samples are being analyzed for manganese, copper, zinc and cobalt.

The soil samples are being used for pH measurements and will be analyzed by "Quick Test Methods".

Title: Establishment and Maintenance of High Quality Pasture Mixtures on Uproductive Lands

Leaders: R. P. Pennington and J. B. Washko

In this experiment legume-grass combinations were seeded at different levels of mineral fertility at five locations in the state.

At State College (Centre County) and at Graterford (Montgomery County) one replication involving alfalfa, Birdsfoot trefoil and Ladino Clover in combination with bromegrass, orchard grass, tall fescue, tall oatgrass, timothy and Reed canary grass was seeded. The fertility levels were 40, 80, and 120 lbs. of added phosphorous per acre, 0 and 100 lbs. of added potassium per acre and one-half and full lime requirement on the Ladino and Birdsfoot trefoil. With alfalfa, the full lime requirement was reached and two levels of boron used 0 and 40 lbs. of borax per acre. These are laid out in a completely factorial design.

At Wernersville (Berks County) the soil needed little or no lime. The same experiment was started except two replications were seeded with Birdsfoot trefoil and Ladino.

In the northeastern section of the state, at Elk Lake (Susquehanna County) where the soil is very poorly drained alfalfa was not seeded. The fertility and lime levels were not changed. The grasses used with Ladino and Birdsfoot trefoil were: Kentucky bluegrass, perennial ryegrass, orchard grass, tall oatgrass, tall fescue, timothy and Reed canary grass. Yield results were obtained on all of these plots during 1951. In all except Elk Lake three cuttings were harvested. At Elk Lake only two cuttings were taken.

These results have not been completely summarized. At State College the alfalfa combinations were the only ones showing a response to fertilizers. This may be explained by a very dry summer.

The alfalfa combinations showed a yield increase with each increment of fertilizer. The most striking were:

A. 40 lbs. borax/acre gave 0.51 T/acre increase
B. 100 lbs. potassium /acre gave 0.53 T/acre increase.

In the fall of 1951 various maintenance applications of fertilizer were applied. Similar applications will be made in the spring of 1952 in an attempt to compare spring and fall applications.

The maintenance applications used were:

A. 200 -- 400 lbs./acre of 0-20-20 and 0-19-19 (with borax)
B. 400 -- 800 lbs./acre of 5-10-10
C. 200 lbs./acre of 0-19-19 and 0-20-20 plus 400 lbs./acre of 5-10-10.

Yield results and chemical analyses will be continued.

All areas in this experiment were seeded in the spring of 1950.

Title: Effect of Nitrogen on the Establishment of Legume Grass Mixtures at Different Levels of Mineral Fertility

Leaders: R. P. Pennington and J. B. Washko

An experiment to test the effect of nitrogen on the establishment of legume-grass mixtures at different levels of mineral fertility was seeded in the spring of 1950 at State College.

The legumes used were alfalfa, Birdsfoot trefoil and Ladino clover, while the grasses were orchard grass and bromegrass. Three levels of mineral fertility were used - 0, 400 lbs. and 800 lbs. per acre of 0-20-20 fertilizer. The N levels used were 0, 20, 40 and 80 lbs. of nitrogen per acre applied at seeding time.

Each main plot contains the legume and one nitrogen treatment. The six subplots are each grass at each level of mineral fertility. This is laid out with four replications in a completely factorial design.

Yields were taken in 1951. These yields showed very little difference due to nitrogen. There was a slight drop due to nitrogen which was not significant. The average yields are shown in Table 19.

Table 19. 1950 Treatments and 1951 Yields (Average)

Treatment	Yield - tons/acre
0N	3.28
20N	3.15
40N	3.13
80N	3.11
Check	3.08
400# 0-20-20	3.14
800# 0-20-20	3.25

Protein analyses have not been determined as yet.

Maintenance applications of fertilizer were put on the plots as follows:

200, 400, 800 lbs./acre	0-20-20
400 lbs./acre	0-19-19 (borax)
600 lbs./acre	0-15-30
800 lbs./acre	5-10-15

Similar applications will be put on this spring.

Yields will be taken and chemical analysis will be made.

Title: Preserving Forage Crops with Sulfur Dioxide

Leader: C. B. Knodt

Sulfur dioxide at a rate of 5 pounds per ton of green material has been used in the preservation of forage crops such as orchard grass, bromegrass, alfalfa, timothy-red clover and pea vines. Comparisons of dry matter losses and various chemical changes have been made between the sulfur dioxide, wilting, cereal grains and untreated methods of crop preservation.

On the basis of feeding trials conducted over the last 3 years it does not appear that the sulfur dioxide added has any harmful effects upon the health of dairy cattle. The losses in dry matter of the crop as harvested appear to be less than 10 per cent with sulfur dioxide as compared to losses of 20 per cent or more of the dry matter occurring with wilting, cereal grains or no treatment. The sulfur dioxide decreases the breakdown of sugars and proteins during ensiling. It decreases the production of lactic acid, ammonia and volatile acids. It reduces the breakdown of carotene.

Not only has the method been proven under research conditions but was used on over 1200 farms in 1951. Surveys of farmers' reactions have been favorable and indicate this method of preserving forage crops as being acceptable to them in respect to labor required, problems in handling and product produced.

Title: Forage Insect Investigations
Department of Zoology and Entomology

Leaders: N. D. Blackburn and John O. Stivers

Forage insect investigations conducted during the 1951 season were concerned with the biology and control of the meadow spittlebug, Philaenus leucophthalmus, and the clover root borer, Hylastinus obscurus. The major objective of the research program was to evaluate the effectiveness of various insecticides applied during the spring for control of immature stages of the spittlebug, and to determine subsequent effects of such applications on both adult and immature stages of the clover root borer.

Insecticides applied to 1/100 acre plots of red clover (Scott variety) in the first harvest year included lindane, benzene

hexachloride, aldrin, dieldrin, and toxaphene. Each, with exception of lindane, was applied at two different concentrations in the form of wettable powders, while both lindane and toxaphene were also applied as emulsion concentrates. All materials were applied in water at the rate of 200 gallons per acre using a Myers wheelbarrow sprayer at a pressure of 225-250 pounds. Each of eleven treatments and an untreated check was replicated five times in a randomized block design.

Eggs of the meadow spittlebug began hatching in the spray plots on April 29, and the peak of adult root borer migration into the field, as determined by tanglefoot-covered screens, occured on May 2. Spray applications were made on May 3 and 4 when the height of the clover was between 3 and 4 inches.

Infestation records taken on June 4 showed that lindane and benzene hexachloride were superior in reducing populations with toxaphene in the form of an emulsion concentrate being slightly less effective. Data taken on June 25 showed significant increases in hay yields (dry weight) of from 20-30% due to effective control of spittlebugs since injury by the root borer occurs later in the season.

Records on root borer damage taken during August and September showed that none of the materials, at the concentrations employed, produced a satisfactory reduction in the number of infested clover roots. Lindane and dieldrin appeared to be more effective in reducing populations of this insect. Plots treated with the latter material had significantly larger numbers of surviving clover plants on October 15. Additional experimental evidence is needed, however, in order to establish any definite conclusions.

Clover sprayed on May 5 with one of the systemic insecticides showed no significant reduction in spittlebug population and only a slight decrease in root borer damage.

Vermont Agricultural Experiment Station

Title: Cytogenetics and Breeding Investigations with Forage Legumes

Leader: A. Gershoy

Autotetraploid Ladino clover, Trifolium repens var. giganteum, 4n(8x)= 64. Five years of maternal line (visual)selection in progeny derived from intercrossed clones yielded foundation seed, in 1951, for seed increase in Oregon. This seed will be available for regional trials. Desirable attributes sought were: continuous seasonal growth, drought resistance, winter hardiness, freely branching stolons, a high flower to foliage ratio and avoidance of exaggerated polyploid characteristics. Plots were seeded in 1950 to earlier genetic selections of 4n Ladino, alone and in grass association. These were harvested, by Mr. K. Varney, along with standard entries in the N.E. 10 trials. The May 1951 cut of 4n was interior but thereafter in each succeeding cut the recovery growth of 4n was superior so as to produce a season's total yield at least as high as the best N.E. 10 entry (Oregon). After the

first cut the flower to leaf ratio was persistently high. In cooperation with Dr. G. Wood, two areas, with four replications in each, were seeded in 1951 alone and in grass associations, to the standard Oregon and Breeder's F. C. 23,608 strains and earlier genetic selections of 4n. A fall cutting, in the seeding year, in one area, showed highest total yield for the Oregon strain and equivalent total yields for Breeder's and 4n.

The facilities of this station did not permit a more rigorous selection, than visual, of parents for use in the foundation seed program. It is evident that a study of plot yields from seeds obtained by intercrossing individual clones could result in a selection of genetic combinations superior to those now comprising the Vermont 4n strain. A further study on a regional basis would be desirable. A small portion of the foundation seed is available for distribution, for this purpose.

Lotus corniculatus var. vulgaris. Three coarse stemmed, leafy, European types have been combined, namely F. C. 22,671, V-101 from Columbia Co., N.Y., and Danish. The latter two were selected from seed supplied by Dr. H. MacDonald. The attributes sought for this synthetic strain, in addition to hardiness, were: coarse stem, large leaves, leafiness, reasonably late period of bloom, determinate flowering habit, rapid growth in large seedlings and vigorous recovery growth. As a result of 5 years visual selection in maternal line progeny of intercrossed clones, parents have been chosen for production of foundation seed in 1952. In cooperation with Dr. G. Wood, bulked earlier genetic selections have been sown in plots, alone and in grass association. The Oregon (Granger) and N. Y. Empire have been seeded as companion strains.

Autotetraploid Lotus tenuis, 4x = 24.
Field observations have been made in maternal lines in the third (C_4) generation of visual selection. Seeds have been collected in clonal polycross nurseries for further selection. Many highly vigorous large plants have been found but progress in desired increase in fertility is slow. Anomalous segregates and characteristic polyploids derived from open pollinations, show a marked increase in pod size but a considerably lesser increase in seed number per pod--70-80% of the seeds in such pods are malformed and of larger size than normal seeds. About 30% of these abnormal seeds germinate at once, without previous scarification, to produce normal seedlings.

The remainder swell immediately and mold. The genetic and cytological nature of the malformed seed will be investigated. With the cooperation of Dr. G. Wood, plot trials for yield will be sown in 1952 of 4x L. tenuis. Bulked seed will be used as well as commercial 2x as control. Individual plants, representative of the range in anomalous and characteristic polyploid types, will be used in diallel cross-pollinations and also crossed with L. corniculatus var. vulgaris as a control.

West Virginia Agricultural Experiment Station

Title: Forage Crops Varieties, Strains, and Species for West Virginia

Leader: O. J. Burger

Yield studies reported in tons at 12 per cent moisture level were made on birdsfoot trefoil, Ladino clover, red clover, and alfalfa growing alone with orchard grass, bromegrass and timothy. The grasses were also grown alone and in association with the above-mentioned legumes. Various management treatments were superimposed. Total yield of the mixtures as well as yield contribution of species in the mixtures were studied. The alfalfa-grass mixtures yielded the greatest total season followed by Ladino clover, red clover, and birdsfoot trefoil-grass mixtures. Birdsfoot-timothy, Ladino-orchard grass, red clover-timothy and alfalfa-bromegrass were the highest yielding mixtures. Viking birdsfoot, Oregon certified Ladino, Dollard red clover, and Narragansett alfalfa were the best forage producers. Narragansett alfalfa was superior in leaf hopper resistance, spittle-bug resistance, and rapidity of recovery after cutting.

Timothy-legume mixtures outyielded orchard grass-legume mixtures which produced more than bromegrass-legume combinations. When orchard grass and bromegrass were grown alone (Nitrogen added) they yielded more than when associated with either Ladino clover or alfalfa. Timothy-red clover outyielded timothy alone and timothy-Ladino. Commercial orchard grass, Fischer-and commercial timothy outyielded their respective species strains.

In the birdsfoot trefoil mixtures the grass contributed the greatest weight to the total yield. Ladino contributed about half; red clover, a little less than half; alfalfa, about half. Of the grass-legume mixtures, orchard grass contributed about 70 per cent to total yield; bromegrass about 60 per cent and timothy, about 40 per cent. The birdsfoot managed as silage yielded as much as that managed for pasture. Ladino clover for silage outproduced that managed for pasture. Pasture managed orchard grass was superior to that managed for silage. The reverse was true for bromegrass.

Bromegrass adaptation plots were seeded at 8 locations in West Virginia. In all but one plot good stands were observed. Elsberry bromegrass appeared to have the best seedling vigor. Seventy-five clonal lines and six checks were seeded also, but no yield or disease data have been taken. This will take place this year.

Title: The Influence of Fertility and Management on Several Ladino Clover-Grass Mixtures

Leaders: O. J. Burger, Newton M. Baughman, D. R. Browning, Department of Agronomy and Genetics

Ladino clover and various grasses were seeded in the spring of 1951. Ladino clover was seeded alone and in combination with Kentucky 31 fescue, Lincoln bromegrass, Beltsville orchard grass, and Reed canary grass. Four fertility levels as well as three management treatments will be super-imposed.

No results to date can be reported. Fertilizer rates are to be applied early in 1952. These are as follows: check, 800 lbs. 0-10-0, 800 lbs. 0-10-10, and 800 lbs. 5-10-10.

Title: The Establishment and Testing of Grass and Legume Species and Strains for Soil Conservation

Leaders: O. J. Burger, Agronomy and Genetics Department; Harry L. Porter and Frank W. Glover, Jr., Nursery Division, Soil Conservation Service

New entries were entered into the observational nurseries. Among these were Panicum clandestinum, various Bromus, Medicago spp. Peruvian alfalfas, and Lotus spp.

Birdsfoot trefoil was seeded with variations of the following treatments: scarification, use of adhesive on seed to attract inoculant, artificial inoculation along with soil from well-established birdsfoot trefoil plants, nitrogen fertilization, and complete fertilizer placement. It was apparent that a treatment that received all the above treatments resulted in obtaining a superior stand. Further observation is necessary.

Italian, Narrowleaf, and Empire varieties of birdsfoot trefoil were seeded on four farms in West Virginia. Birdsfoot trefoil was seeded in such a manner as to allow seed to fall about an inch above the fertilizer band. Good stands were observed in all but one farm. Here inoculation was not completely effective.

Various grass species, namely, tall fescue, timothy, bromegrass, orchard grass, and a check were seeded across the birdsfoot varieties. The tall fescue mixture appears to be doing noticeably well on one farm which is located at an altitude of approximately 1500 feet.

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