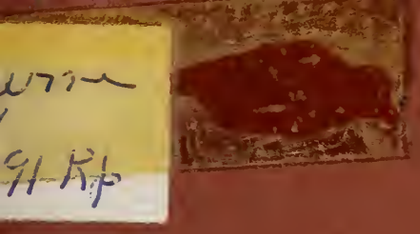

TWENTY-FOURTH ANNUAL REPORT

of

Pasture Research

in the

Northeastern United States
University Park, Pennsylvania

1960

FOR ADMINISTRATIVE USE ONLY

1960

Twenty-fourth Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
University Park, Pennsylvania
Forage and Range Research Branch
Crops Research Division,

Eastern Soil and Water Management Research Branch
Soil and Water Conservation Research Division,
and
Grain and Forage Insects Research Branch
Entomology Research Division
of the
Agricultural Research Service
U. S. Department of Agriculture

and

The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

- - - - - - - - -

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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B.

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Lois L. Smith	Secretary

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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 reproduced in limited numbers, it is not available for general distribution to individuals outside the Region.

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PASTURE RESEARCH IN THE NORTHEASTERN UNITED STATES

This report, the twenty-fourth in the series, was prepared by and is intended primarily for use of personnel engaged in forage research in the twelve Northeastern States. It contains a summary of progress during 1960, reflects an appraisal of northeast problems and provides information that leads to coordination benefiting all states. Included are reports from research scientists at the U. S. Regional Pasture Research Laboratory, from the northeast forage crops technical committees, from research workers at the state experiment stations and from personnel of the Forage and Range Research Branch at Beltsville, Maryland.

Collaborators assembled materials from their respective stations, chairmen of regional technical committees supplied copies of their annual reports and research scientists at the Pasture Laboratory and at Beltsville prepared descriptions of their forage research related to this region.

At the Pasture Laboratory, two personnel changes occurred. The vacancy in the position of soils research scientist was filled in August by Dr. Stanley R. Wilkinson who completed requirements for the Ph.D. at Purdue University in June 1960. The position of Agronomist in Charge at the Laboratory and the research scientist in plant breeding became vacant in December when Dr. H. L. Carnahan left to assume responsibility for the alfalfa program in the Southwest. He is stationed at Reno, Nevada and this research vacancy at the Pasture Laboratory has not yet been filled. Vance G. Sprague will continue as research scientist in physiological and agronomic studies while serving as Plant Physiologist in Charge of the Pasture Laboratory.

A Collaborators' Conference, concurrently with meetings of Directors of Experiment Stations and Regional Forage Crop Technical Committees, was held at the U. S. Regional Pasture Research Laboratory August 23 to August 25, 1960. In addition to the Collaborators, guests from several experiment stations, a number of A.R.S. representatives from Crops, Soils and Entomology with offices in Washington and Beltsville, and the Laboratory Staff attended the sessions. Members of the Laboratory Staff presented reports of their current research.

In accordance with the Memorandum of Understanding dated September 30, 1959, the Collaborators elected B. A. Brown (Connecticut) as their chairman with M. A. Sprague (New Jersey) as secretary. *On the afternoon of August 25, a meeting was held under the leadership of B. A. Brown and suggestions were presented by all stations which dealt with future activities and the needs for expanded work at the Laboratory. Many of these items had been suggested at previous meetings and discussion also centered on the financial problems involved in implementing them. Among the suggestions presented was the desirability of adding a soil microbiologist to the laboratory staff. It was also suggested that perhaps fundamental problems in soil microbiology might be best studied, where nematology and bacteriology could also be investigated

* Parts of the above report of the Collaborators' meeting were abstracted from the secretary's minutes.

in relation to pasture plant pathology and nitrogen fixation. The desirability of adding facilities at the Pasture Laboratory for animal evaluation of plant products was recognized, but this would involve major additions. It was indicated that in such cases as these where major innovations are regarded as important, backgrounds must first be laid to provide cases to be considered for action by the administration. It was then pointed out that a primary function of the Collaborators is to identify existing problems and not necessarily present hard and fast recommendations for their solution.

As in many past conferences, the feeling was again expressed that exchanges of ideas be encouraged by more frequent visits of Laboratory personnel with state scientists at their own stations. From the standpoints of time and fiscal budgets, travel presents problems, and in the summer, when field observations are best made, scientists are reluctant to interrupt their own field work. It was definitely pointed out, however, that exchanges of ideas during personal contacts are highly desirable.

A list was drawn up of a number of problems that warrant consideration at the Laboratory. Some of these are currently under study at the Laboratory and in Beltsville.

1. Legume-grass competition as affected by climate, nutrition and management.
2. Competition for survival by Ladino clover.
3. Fundamental work in plant breeding.
4. Basic work with root studies.
5. Fundamental work on climate values.
6. Alfalfa weevil control.
7. Evaluation of new species for forage purposes.
8. Improvement of permanent pastures.
9. Greater availability of laboratory research teams for pressing regional problems.
10. More extensive exchange of ideas of Laboratory and State researchers.
11. Review of the needs of the Laboratory to conduct research.
12. Periodic review of research at State Stations was suggested. This would aid in coordination of research in the region and encourage cooperation between States and between the States and Laboratory personnel.

The need was recognized of planning in advance for the next program, submitting proposals for discussion and determining frequency of Collaborators' meetings. The chairman was authorized to appoint a work group to bring the problems before the Laboratory and A.R.S. Beltsville personnel in early spring 1961.

RESEARCH AT THE PASTURE LABORATORY

GENETICS, PATHOLOGY AND ENTOMOLOGY

Alfalfa

Breeding and Genetics of Adapted Root-spreading Alfalfa

Degree of root-spreading was rated on individual plants of 15 single crosses (6-clone diallel), the parental clones and the check variety Rambler established in 1959. Root-spreading was rated in April and October on individual plants using the following scale: 1 = 100-200 shoots arising independent of the center crown (maximum spreading); 2 = 50-100 shoots; 3 = 15-50 shoots; 4 = 1-15 shoots, 5 = broad crown but no independent shoots; 6 = crown typical of narrow-crowned upright varieties. Classes 1-4 inclusive were considered root-spreading when calculating percent of plants expressing this habit. One year following transplanting as seedlings the single crosses ranged from 29.7 to 75.3 percent plants with some degree of root-spreading in contrast to 13.7 percent for Rambler. In addition, root-spreading and rate of recovery following harvest of certain individual plants exceeded that of the better parent in this study.

From a second nursery established in 1959 of crosses between root-spreaders and upright, wilt-resistant non-spreaders, 20 clones were selected for backcrossing to desirable hay type with disease resistance.

Approximately 4 pounds of Syn 2 generation seed of a 3-clone synthetic (56-128, 56-129, and 56-140) were produced at Logan, Utah in 1960. This entry will be compared with Rambler and birdsfoot trefoil in a grazing trial to be established in cooperation with Department of Agronomy, The Pennsylvania State University. The Syn 2 material will also be established in 1961 to serve as source material for new selections for root-spreading types with greater leaf disease resistance.

Partial Male Sterility in Alfalfa

There is limited genetic information on the inheritance of partial male sterility in alfalfa. As source material for a newly initiated study the clones C184-5 and C191-4 were used. Both had 2n = 32 chromosomes and approximately 25 percent stainable pollen. Reciprocal crosses were attempted, but hybrids were produced only from C184-5 x C191-4. Stainable pollen of hybrids ranged from 0 to 71 percent, suggesting that the low amount of stained pollen of C184-5 was apparently under genetic rather than cytoplasmic control. Representative plants had 2n = 32 chromosomes. The hybrids and selfed progenies of C191-4 were rated for amount of normal pollen grains by using the following four classes: 1 = 300-800 normal pollen grains per floret, 2 = 50-300, 3 = less than 50, and 4 = none. Plants with more than 40 percent stained pollen generally produced more than 300 normal pollen grains per floret, plants with 16-40 percent stained pollen released between 50 and 300 pollen grains, and plants with less than 15 percent stained pollen released either none or fewer than 50 normal pollen grains per floret. The pollen production estimates were in fair agreement with pollen stainability but were less accurate. Crosses between plants varying in stainable pollen were made for genetic analysis.

Reciprocal Differences in Single Crosses

The genetic model used for diallel analysis (1958 Annual Report, page 6) required the assumption that reciprocal crosses gave the same results. Since limited information is available about maternal (cytoplasmic) effect in alfalfa, a more detailed study was made. One set of material was based on alfalfa clones that had been selected from a 7-year old polycross progeny test seeded at Connecticut in 1951. Hand-crossed seed of high quality was obtained in the greenhouse from 16 different cytoplasm sources present in 95 single crosses. In a preliminary experiment with this material, there was no statistically significant average maternal effect on seedling height at 4 weeks.

Sixteen crosses with separated reciprocals were used in a more detailed study. Pregerminated seeds were planted in 4-inch glazed pots and thinned to 7 seedlings in each of 4 replications. Height of 4-week-old seedlings (heritability = 45 percent) was significantly different in 3 of the 16 reciprocals. Yields at first harvest (4 weeks) and at second harvest (8 weeks) resulted in respectively one and no cross with significant reciprocal difference. Heritability for yield at 4 weeks of age was 53 percent. There were highly significant positive correlations between seed weight and "unifoliolate leaf area", r = 0.78, n = 32; and between unifoliolate leaf area and seedling height at 4 weeks, r = 0.47, n = 32.

In each case where a significant maternal effect was demonstrated, the reciprocal with greater height or weight also had heavier seeds and larger unifoliolate leaves.

In another set of material, hand-crossed seed was produced between C303 and C640, two clones represented in the 14-clone diallel of 1958. A highly significant reciprocal height difference was obtained at 4 weeks of age but no difference at first harvest in early bloom. There was a significant positive correlation between seed weight and plant height of 4-week-old seedlings, $r = 0.80$, $n = 6$. When seed was used that had been produced under bee-cages in California, reciprocal differences were found at 4 weeks of age, and at first and second harvest. These differences resulted from presence of selfed progenies, possibly because C640 was a late flowering clone in contrast to C303. The deviating performances of selfed progenies compared to the hybrids resulted in reciprocal differences which were maintained during the experiment. When selfing can be excluded, maternal effects in alfalfa are very likely to be the result of seed weight difference between parent clones. Seed weight, with only a transient effect on plant vigor, may be of sufficient magnitude to be of practical consideration with respect to successful stand establishment.

Selection for Disease Resistance in Alfalfa

The program to develop materials with resistance to foliar pathogens was continued. The 117 selected plants (1959 Annual Report, page 5) were reduced to 96 and propagated vegetatively for a 1961 polycross nursery to be established in Utah for seed production. Clones C318 and C319 were added to the above group to make 98 clones. Tests are also planned to determine the relationship between seed and forage yields.

In the spring of 1960, approximately 7200 seedlings from crosses among the 117 1959 selections and selfs from these clones were started in flats and reduced to about 4600 on the basis of artificial inoculations with Pseudopeziza and Ascochyta and elimination of weaker seedlings. The 4600 were established in a field disease nursery as in previous years. From this nursery, 100 selections representing 27 crosses and 30 selfed lines were made in the fall of 1960. Disease resistant selections were taken only from crosses or selfs, the parents of which were selected from crosses having estimated vigor equal to or exceeding that of Vernal.

The 1960 selections were inoculated artificially with Pseudopeziza and survivors will be sibbed to further concentrate disease resistance with a minimum of inbreeding. This will also provide materials directly descended from 1959 clones, the performance of which should be predictable to some extent, from the polycross performance of 1959 clones.

If a few clones appear outstanding in Pseudoplea resistance, a synthetic based on this resistant material can be made.

Rapid Screening of Alfalfa for Resistance to Corynebacterium Insidiosum

The petiole method of inoculation continues to be effective (1959 Annual Report, page 6).

Some of the same seedlings that were inoculated by the petiole method in the 1959 test were tagged (using a code) and reinoculated by the same method. The ratings agreed very closely, indicating repeatability of the petiole method.

To compare the petiole method with the commonly used root-soak method, the same seedlings that had been inoculated by the petiole method were dug and their roots washed, clipped and soaked in a bacterial suspension. Notes were taken on foliar symptoms at 3 dates, and after 3 months plants were dug and rated according to the amount of internal discoloration caused by the bacteria.

Agreement was good between petiole inoculation and the root-soak method. However, there were a few exceptions as one would expect in biological research. The main difference between the two methods concern time and labor. Using the petiole method, ratings were made 9 weeks after planting while 23 weeks were necessary for the root-soak procedure. Much more labor and greenhouse space are required by the latter method. A seedling can be inoculated in 30 seconds by the new method, while a much longer time is necessary for the old method.

The 1959 test with varieties of alfalfa was recently repeated with other isolates of Corynebacterium insidiosum. The percent placed in the resistant class was: Vernal - 46%, Buffalo - 28%, Ranger - 22%, Narragansett - 7%, DuPuits - 2%, and the Italian strain - 8%. Seedlings in this test have been tagged (resistant, intermediate, and susceptible) and reinoculated by the Canadian root-ball method. Final notes will be taken in April 1961.

Rating Alfalfa for Resistance to Spittlebugs

Plants in a root-creeping clonal nursery had been evaluated for numbers of spittle masses and nymphs per mass in previous years. In 1960 all clones were rated visually for spittle masses on the basis of 1 = least, 10 = most. Environmental differences were greater than plant differences, indicating that plants with little or no infestation should be rated in several seasons.

Selection for Potato Leafhopper Resistance

Since previous selections for leafhopper resistance from varieties such as Culver were completely unsatisfactory in leaf disease resistance, selections were made in 1960 from 1958 and 1959 disease nurseries and from 1960 leaf disease resistance holdover nursery. A total of 53 clones with apparent resistance to leafhopper yellowing were selected and brought to the greenhouse for crossing. The clones and their progenies will be evaluated further in 1961.

Combining Disease and Insect Resistance

Two replicates of 10 plants per entry per replicate of 133 single crosses and five check varieties or synthetics were established in July and overseeded with timothy in September. These single crosses had been made between clones selected for resistance to leafhopper yellowing in 1958 and 1959 and dark green clones selected for resistance to leaf diseases. Analysis of variance for Pseudopeziza, involving respectively a 8x8 and 9x6 parent clone arrangement, gave highly significant general combining ability estimates. The specific combining ability estimates were not significant, presumably because only two replicates were used. Results suggested that Pseudopeziza reaction was conditioned by genes with predominantly additive effect. The best single cross, 59-3 x 59-101, had a mean reaction score of 1.45 (0 = immune) whereas the means for Buffalo, Culver, Vernal, New York Syn A and North Carolina Syn E were respectively 8.60, 6.05, 5.70, 8.70, and 7.25. Data on reaction to leafhopper injury will be obtained on second growth in 1961.

Potato Leafhopper and Adult Spittlebug Injury on Alfalfa

Adult male and female potato leafhoppers produced differential injury on alfalfa. Females caused several times as much wilting as males; they induced both trifoliolate and top wilt while males caused only trifoliolate wilt. Alfalfa infested with an average of 9 females per plant produced one half as much growth as plants infested with an equal number of males.

Adult spittlebugs retarded growth when caged on alfalfa. One hundred adults caged 8 days on potted alfalfa retarded growth by an average of 5.3 inches, and reduced green weights by an average of 6.4 grams under check plants.

Survey for Alfalfa Weevil in Pennsylvania

The alfalfa weevil was found in Allegheny and Jefferson Counties, Pennsylvania for the first time this year. It first appeared in Centre County, Pennsylvania in 1957. Only moderate larval and adult populations occurred there in 1959. This season larval populations increased sharply in June and many fields received some injury.

Coumestrol in Alfalfa Varieties at Different Locations

This station is participating in cooperative tests designed to obtain information on possible differences in coumestrol content among the 5 varieties: Buffalo, DuPuits, Lahontan, Ranger, and Vernal. Samples were taken at each of 3 harvests from 4 replications and forwarded to Albany, California for analysis. Agronomic and climatological data were also taken for study of the possible environmental influence on quantitative development of coumestrol in alfalfa.

Ladino and Other Clovers

Interspecific Hybridization and Cytogenetics

To ascertain causes for species incompatibility, previous methods used for pollen-tube growth in smeared stylar tissue have been unsatisfactory. A technique was developed by Martin (1959) to observe pollen tubes in smeared styles of tomatoes. After pretreatment and staining in aniline blue, pollen tubes fluoresced with UV illumination and dark field. The technique which was tried successfully with limited material of clover and alfalfa will be used in an attempt to determine whether previously obtained cross-incompatibility between clover species is associated with inadequate pollen-tube development.

Since it is unknown whether interspecific clover hybrids may be SC as a result of interaction between self-incompatibility alleles (SI) of parent genomes and whether SC of one parent genome results in SC of the interspecific hybrid, four triploid (2n = 24) hybrids between T. repens (2n = 32) and T. nigrescens (2n = 16) and their hexaploid derivatives were studied. The T. repens parent was heterozygous SC and self-fertile, the T. nigrescens parent was SI. Thus, the triploids contained one SI nigrescens-genome and one repens-genome which was either SI or SC. Hexaploid derivatives would possess two SI alleles from the nigrescens parent and two alleles, either SI or SC, from the repens parent.

The self-sterile triploid hybrids had less than 16 percent stained pollen but colchicine-treated stolons produced chimaeras with approximately 85-100 percent stained pollen. The four derived hexaploids (2n = 48), which were established from these branches in separate pots, were selfed. Two plants remained SI, suggesting that the SI alleles of the parent genomes did not interact to produce self-compatibility. The two SC derivatives presumably possessed SC alleles from the T. repens parent.

Since monosomic white clover, which would be a valuable tool in genetic analyses, is not available, a backcrossing program was initiated. Triploid (2n = 24) T. repens x T. nigrescens interspecific hybrids were used as source material. Six BC_1 plants (2n = 28) were obtained from approximately 500 pollinations. Whereas the triploid hybrid had 16 percent stainable pollen the BC_1 plants ranged from 19.8 to 50.3 percent. Preliminary attempts to obtain BC_2 resulted in 26 seeds from 40 pollinations, but more extensive crossing is planned for 1961.

The chromosome number 2n = 26 was determined from root tips of the following four annual species: T. clypeatum (Israel); T. scutatum, PI 202808; T. spumosum (Israel); and T. vesiculosum, PI 233816.

Inheritance of a Red-purple Leaf Marking in Ladino White Clover

One Ladino white clover plant with red-purple markings shaped as a V on young leaflets but extending toward the margin on mature ones was found by Mr. P. Taylor in a pasture in Georgia. Another plant was found in South Carolina by Dr. P. B. Gibson, suggesting that this leaf marking is rare. Two F_1 genotypes were used for genetic studies, both heterozygous for the red marking but one heterozygous and one homozygous for white leaf marking. The F_1 plants were crossed with self-incompatible testers which were green without markings. The F_2 populations were obtained by intercrossing the self-incompatible F_1 plants. The testcrosses and F_2 segregated red to green, respectively 1:1 and 3:1, suggesting that this red leaf marking was simply inherited and controlled by one dominant gene. Additional testcrosses showed this gene to be very closely linked to the V-marking alleles (described by Brewbaker and Carnahan) as determined by a crossover value of 0.1 percent. The symbol V^r is proposed for the gene controlling this red leaf marking. The low crossover value does not rule out the possibility of mutations at the V^r locus. More critical studies of the other V-alleles may show a compound locus rather than a simple allelic series.

Selection for Persistence in Red Clover

Thirty-nine red clover plants selected for persistence were cloned and established in the field with 2 to 8 replicates of 5 plants per row for seed production. From 4 to 113 grams of "polycross" seed were harvested from these clones in 1960 for use in seeded-plot progeny evaluation for persistence.

Internal Breakdown in Crown Tissues of Red Clover

Results of tests have still not revealed the cause or control of internal breakdown in red clover. Some leads, however, have been obtained. For example, there are indications that rapidly growing plants (larger crowns) have a higher incidence of IB, while in some tests minor elements appear to be an indirect factor. The genetical approach seems to be the most promising means of control. Experiments dealing with these and other factors were conducted during 1960.

From 1959 and 1960 tests, it is concluded the IB is not caused by a deficiency or toxicity of minor elements. A slight indirect minor element effect which was sometimes indicated, could have been due to growth-rate differences or some unknown factors.

Bacteria are commonly isolated from IB tissue and also from internal crown tissue not showing discoloration. Bacteria from both sources were used to inoculate young red clover seedlings by inserting them into the crown with a needle. Some of the seedlings were also drenched with a bacterial suspension. After 5 months approximately 50 percent of the inoculated and non-inoculated seedlings developed IB. Inoculations with the commonly isolated fungi Chaetomium sp., Fusarium spp., and Phoma sp. were also negative.

General observations suggested that if the crowns of red clover plants were raised slightly above the soil level, the incidence of IB was lower. An experiment was initiated to test this observation. Soil was removed from the crown area of a series of 6-week old seedlings and another series was used as a control. Results of the test (30 seedlings) indicated that the incidence of IB was unaffected.

As previously indicated (1959 Annual Report, page 13), the incidence of IB appears to be genetically controlled. Over 1200 F_2 seedlings from Non IB x Non IB and IB x IB crosses were rated for IB after 6 months of growth.

By crossing IB plants, the incidence of IB of F_2 seedlings was 98-100 percent, while crosses among plants not having IB showed from 40-100 percent IB. Pennscott seedlings of the same age (6 months) averaged around 65 percent. Thus the incidence was greatly increased by crossing IB plants but affected only slightly by crossing Non IB plants. An F_3 generation has been produced and will be rated for IB in 1961. Likewise, the percent of F_2 seedlings with black dots (physiological spotting) was much greater from crosses of IB x IB parents. Attempts to isolate pathogens from the black dots have been negative.

The F_2 seedlings that were free of IB were repotted and examined again when 8 months old. Eight crosses that showed the least amount of IB on this date were divided vegetatively and repotted. These plants were later transplanted into two bee cages (4 clones in each) for seed production. In 1961, plots will be established using F_2 seed from IB x IB plants and Non IB x Non IB plants and their persistence noted. This test will be in conjunction with our selections of red clover for persistence.

Species of Leptosphaerulina (Pseudoplea) on Forage Plants

Leaf-inhabiting Ascomycetes characterized by ellipsoid, phragmosporous, or dictyosporous, hyaline to brown ascospores and bitunicate, saccate asci arising individually within the centrum parenchyma of small, spherical, membranous ascocarps are placed in the genus Leptosphaerulina (Syn. Pseudoplea). Of the 6 species recognized on forage plants in the United States, L. australis McAlp., L. argentinensis (Speg.) comb. nov., and L. americana (Ell & Ev.) comb. nov. characterized respectively by 4-, 5-, and 6-septate, dictyosporous ascospores are saprobes. The other 3 species are pathogens of legumes. L. trifolii (Rost.) Petr. causes pepper spot of species of Trifolium and is potentially capable of producing severe to moderate infection on other legumes, including species of Medicago, Melilotus, Pisum and Vigna. Its low temperature requirement for sporulation limits its occurrence to the cooler period of the growing season. L. trifolii typically produces large, 3-septate, phragmosporous ascospores and differs from all other species in its slow growth rate in culture. Although L. briosiana (Poll.) comb. nov. is of importance as the cause of leaf spot of species of Medicago, it is potentially capable of producing moderate infection on Trifolium spp. and mild infection on other legumes. Because of its slightly higher temperature requirement for sporulation, it differs from L. trifolii in seasonal occurrence but it also is a cool-weather pathogen. The dictyosporous ascospores are 4-septate. L. arachidicola Yen, Chen & Huang, is restricted to species of Arachis. It sporulates at temperatures as high as 30°C. and causes a leaf spot during the warm summer months. The ascospores, although 4-septate, are smaller than those of L. briosiana, most closely resembling those of L. australis. Under suitable conditions on dead leaves or in culture on 20 percent, V-8-juice agar all species develop mature ascocarps in less than a week. Airborne ascospores appear to be the only source of inoculum. The pathogenic species generally require light for sporulation; the saprobic species may fruit in darkness.

Spittlebug Injury

Adult Spittlebug Injury on Red Clover

Adult spittlebugs retarded growth when caged on red clover. One hundred adults confined 10 days on potted cut red clover shortened plants an average of 2.2 inches and reduced green weights by an average of 2.3 grams under check plants.

ORCHARDGRASS

Breeding Improved Dactylis glomerata

A polycross nursery was established in 1960 with 5 replicates of 5 plants per replicate of each of 82 clones selected in 1959 (1959 Annual Report, page 15) and the 4 parents of Pennlate. Rust notes were taken on 2 replicates of this late-maturing orchardgrass polycross nursery on 8-12-60. Two clones of Pa. 55-L-3 Syn were outstanding. Heritability for leaf rust was calculated as 79.8 percent. While rust had not been a problem on the source nursery from which these clones were selected, that nursery had been clipped more frequently. Rust resistance may be of primary importance in relation to maintaining parental clones of released synthetics and in successful seed production.

A possible relationship in change in protein and lignin contents of heading and non-heading orchardgrass at successive stages of development may prove of interest. Possibly Dr. Sullivan's results should encourage the development of types that would be non-flowering in the area where grown for forage production.

Male Sterility in Orchardgrass

All plants from crosses of the type (male sterile x male fertile) x male fertile (1959 Annual Report, page 15) flowered in 1960 and were classified as male sterile (non-dehiscent anthers) or male fertile (dehiscent anthers). A few plants barely shedding pollen were classified as sterile-minus. The crosses showed several different ratios of fertile to sterile plants, 1:1, 1:3, 3:1, 7:9 and 9:7. These differing ratios, obtained when crossing different male steriles onto the same male fertile tester, strongly indicate that more than one locus is involved in male sterility and that a male sterile may be heterozygous for more than one locus.

Male fertile plants from two crosses, 58-7 and 58-9, were selfed in 1960 and S_1 seedlings are growing in the greenhouse 1960-1961. It was planned to identify heterozygous male fertiles to use as pollen parents in crosses with normal orchardgrass. Such crosses would then be selfed to ascertain whether male sterility could be expressed independently of the cytoplasm in which the present male sterile characters exist.

Survey of Insects on Orchardgrass

A resurvey of orchardgrass gave essentially the same list of abundant insects as occurred in 1958. (1960 Annual Report, page 15). Principal differences were a decrease in crickets and plant bugs, while aphids, flea beetles and the leafhopper Latalus sayi became moderately numerous.

Lolium-Festuca

Selections for Fertility in Derivatives of Intergeneric Hybrids

Individual plant data were recorded for 535 plants derived from two tetraploid derivatives of the triploid Lolium-Festuca hybrids (55-379(8) and 55-516(2)) that were established in 1959 (1959 Annual Report, page 17). Of these plants 75 to 80 percent shed some pollen. Most plants had spikes, two had panicles and a few had intermediate inflorescences. Open-pollination seed was harvested from more vigorous plants for possible use in progeny evaluation. In addition 40 most vigorous derivatives of 55-379(8) and 34 of 55-516(2) were brought into the greenhouse to determine chromosome numbers. Thirty of the 40 from 55-379(8) were 2n = 28 and the other 10 were triploids 2n = 21. Only 3 from 55-516(2) were tetraploid, while the 2 plants with panicles were 2n = 14 and the other 29 were triploids. These vigorous tetraploids are to be propagated vegetatively and established in a polycross nursery in 1961. All the tetraploid selections except 4 flowered within one day of each other in the field. Two were earlier and two were later. The two diploids flowered 4 days earlier.

Collections were made from the 2n = 28 selections for study of meiotic behavior.

In a previous year amphiploids derived from L. perenne 2x X F. elatior 4x were crossed with tall fescue. These 3-way hybrids were then permitted to open-pollinate with tall fescue. Seed from 29 maternal parents was planted in 1960 in a nursery of 765 plants. Open-pollination progenies of several Kentucky intergeneric hybrid derivatives were included as reference material. Leaves of the Pasture Laboratory derivatives remained greener in the late fall and were less harsh than those of the Kentucky derivatives. The plants showed considerable variation in vigor and softness of foliage.

In making 1961 selections from the 1960 nursery these characteristics as well as pollen-fertility should be considered. Possibly animal acceptance data might be obtained for any selections that prove otherwise desirable and useful.

Cytogenetics of Kentucky *Lolium-Festuca*

Major effort is being devoted to cytogenetic analysis of intergeneric hybrids and backcrosses of these to annual and perennial ryegrasses that have been produced in R. C. Buckner's program at Kentucky. Such information should prove valuable in planning future crosses and formulating synthetics. It may also provide a basis for interpretation of sterility and segregation patterns in this material.

Tall Fescue

Meiosis and Genome Homologies

The S_1 plants studied previously (1959 Annual Report, page 16) were selfed in 1960. Self-fertility appears to be largely independent of meiotic phenomena. S_1 plants that were most irregular in meiosis proved to have the usual complement of 42 chromosomes characteristic of tall fescue. A note is being prepared for publication on the results of this study.

Survey of Chromosome Numbers in Grasses

On a list of available introductions of grasses were 138 species for which no chromosome counts were available. Introductions of *Bromus*, *Festuca*, and *Arrhenatherum* were obtained and most of the seed proved viable. Chromosome numbers were determined from root-tip smears and herbarium specimens were preserved where possible. Two species of *Bromus* and two of *Festuca* as identified in the introductions showed intraspecific variation in chromosome number. Diploid forms of *B. pseudodanthoniae* flowered earlier and were less vigorous than tetraploid accessions. Possibly the vegetative as well as seed-producing characteristics of the tetraploid might make it a winter cover crop. Winter survival needs to be checked before such use of this species can be determined. An introduction of *Festuca sclerophylla* resembled *F. arundinacea* in vegetative characteristics. Should this be a valid species, it may be closely related to *F. arundinacea* and perhaps should be studied cytogenetically.

Bromegrass

Selection for Disease Resistance

Further notes on vigor and reaction to Helminthosporium bromi were taken in the nursery established in 1959 (1959 Annual Report, page 16). On the basis of these notes, 70 of the original 167 clones were permitted to interpollinate. Open-pollination seed was harvested in 1960. Observation in late summer on aftermath recovery served as a basis to reduce this group of clones to 19 for a restricted polycross nursery to be established in 1961.

Scolecotrichum graminis on Grasses

There are no reports in the literature describing methods of inducing S. graminis to sporulate abundantly in culture, and producing the disease in epidemic proportions in the greenhouse. It is believed that the lack of resistant varieties of grasses can be traced to the lack of reliable inoculation techniques. Since brown stripe, caused by S. graminis, is prevalent on so many grasses, considerable effort has been exerted to solve these problems.

Methods have been improvised for the development of sporulating cultures of Scolecotrichum graminis and for the production of the disease at will in the greenhouse. It is now possible to carry on an effective screening (breeding) program for resistance to this disease. Evidence is presented that forms of S. graminis are present. Isolates from orchardgrass infect only that host and isolates from tall oatgrass attack only tall oatgrass. Since the isolates are similar morphologically but attack different plant genera, formae novae are suggested.

Diseases of Bromus inermis

During spring and summer, 1960, space-planted clones selected for resistance to Helminthosporium bromi, Stagonospora bromi, Rhynchosporium secalis, and Rhizoctonia were examined at 7-14 day intervals to determine the kinds and relative prevalence of foliar diseases.

Very few disease symtpoms were present during May. Through June and July the most prevalent and damaging disease was scald caused by Rhynchosporium secalis. Stagonospora bromi was consistently isolated from brown elongated lesions during this period from both the first and second growth of the grass. The

disease did not cause serious damage. Brown spot caused by Helminthosporium bromi was also present but not serious.

Other fungi isolated from disease lesions in order of frequency were Epicoccum nigrum, Ascochyta sp., Phoma spp., Helminthosporium sativum, Colletotrichum graminicola, and Fusarium spp.

During November and December, 7-week-old seedlings of Lincoln and Manchar bromegrass, timothy, orchardgrass, and tall oatgrass were inoculated by spraying with conidial suspensions in the greenhouse. Helminthosporium sativum was very pathogenic on the bromegrass varieties, causing severe leaf spotting, and mildly pathogenic on orchardgrass. Stagonospora bromi attacked only bromegrass and the other fungus species were not pathogenic on any of the grasses. The Ascochyta and Phoma isolates were also tested on alfalfa seedlings but produced no disease symptoms.

Inoculation of Bromegrass with Ascospores and Conidia of Helminthosporium bromi

A greenhouse experiment was set up to determine the optimum temperatures for disease development, using ascospores and conidia. For ascospore production, cultures on PDA and V-8 juice agar were incubated at 5°-10°C. for 4 months. Cultures were incubated at 18°-22°C. (in laboratory) for 2 weeks for conidia production. Temperatures for the inoculation were 16°, 20°, 24° and 28°C. There were 4 replications (4 pots) of brome seedlings.

The main result from the experiment was that infection was moderate to severe at all temperatures with both ascospores and conidia. At 16°C. disease was slower to develop than at other temperatures.

Physiology of Stagonospora bromi

The optimum temperature range for pycnidial formation on lima bean agar was 20-25°C. and for spore discharge, near 20°C. It was also found that spore discharge at 20°C. was greatly increased when mycelium was transferred from a culture previously grown at 15°C. This result was not obtained when mycelium was transferred from cultures previously grown at 20° and 25°C. However, most of the colonies which developed at 20°C. were abnormally small, irregular in outline, and had a "diseased" appearance. The nature of the abnormality will be further investigated.

Disease Resistance in Red Clover as Affected by Magnesium, Potassium, Calcium and Boron Fertilization

An exploratory experiment was established to evaluate the effect of certain proportions of magnesium, calcium, potassium, and boron on the resistance of red clover to infection with Pseudoplea and Stemphylium, as well as the effect of the fertility treatments and disease inoculations on the development of internal breakdown in red clover crowns. No data had been taken at the end of the year. This study will be continued in 1961.

BIOCHEMISTRY, PHYSIOLOGY AND SOILS

Carbohydrate Studies on Grasses

(In cooperation with D. G. Routley of the New Hampshire Station)

At present carbohydrate studies are confined to (1) holocellulose as a source of hemicellulose and (2) the properties and ease of hydrolysis of hemicelluloses in different forages.

It was reported previously (1959 Annual Report, page 19) that when holocellulose was used as the source of hemicellulose considerable losses occurred in (1) the preparation of holocellulose and (2) the hydrolysis of hemicellulose. Further work showed that treatment of holocellulose by hot water alone caused considerable breakdown of hemicellulose and as the extracts became acid during the treatment the extractions were essentially hydrolyses. The use of buffered water reduced these losses considerably. Extraction with alkali at room temperature was a more promising method of removing the entire hemicellulose complex from the holocellulose quantitatively and without much breakdown.

The other source of error encountered, losses during the preparation of the holocellulose, was further investigated. It was hoped that a procedure could be designed to prepare holocellulose quantitatively. The various steps which have been used by one worker or another for this purpose were examined individually and not in combination as heretofore. These were carried out not on the original plant material but on the residue from a benzene-alcohol extraction and consisted of extraction with hot water, and with buffer, autoclaving with water, extraction with hot ammonium oxalate solution, digestion with pepsin, sodium lauryl sulfate, sodium benzenesulfonate, and sodium chlorite. Every one of these treatments, without exception, caused some loss of hemicellulose constituent. Losses were especially high in the galactose and arabinose constituents. Xylose was the constituent least affected and xylans are apparently very stable under many conditions. A relatively high loss of galactose occurred also during the extraction with benzene-alcohol, a procedure expected to remove only lipids and some alcohol-soluble constituents. This suggests the presence of a galacto-lipid compound in orchardgrass.

It is obvious from these studies that holocellulose is not an ideal substance for the isolation and study of hemicelluloses and it will not be used in the future.

As the quantitative isolation of hemicelluloses seems so far unattainable, the study of their hydrolysis *in situ* is being emphasized. Preliminary experiments indicate that acid hydrolysis of hemicelluloses is less rapid in more lignified material. If this is so, there may be some similarity in the manner in which hemicelluloses break down under laboratory conditions and in the rumen. The measurement of the various constituents released during hydrolysis under various conditions is being studied with the hope that these results will give information on the structure of hemicelluloses and on their nutritive value.

Studies were continued on various cellulose preparations isolated from forage plants. Attempts to hydrolyze these quantitatively to glucose were unsuccessful, some loss of glucose occurring, some xylose being always present, and some cellulose being susceptible to hydrolysis by rather mild acid treatments. It is obvious that there is no sharp dividing line between cellulose and some other polysaccharides.

Comparison of Flowering and Nonflowering Orchardgrass Plants

A number of orchardgrass plants in a spaced nursery did not head and flower in 1959. Some were harvested for chemical analysis in 1960 and each nonheading plant was compared with an adjoining plant from the same cross which had emerged and flowered the previous year. The results are summarized in Table 1. The nonheading plants show the same changes as do the heading plants with the onset of the season, namely a decrease in protein, an increase in lignin, and a reduction in the digestibility of the cellulose but the changes in the nonheading are in a much smaller degree. The nonheading plants appear to be higher in nutritive value than heading plants when compared at the same date. The cellulose digestion was determined by the *in vitro* technique by T. V. Hershberger of the Pennsylvania Station.

Table 1. Composition of heading and nonheading orchardgrass plants at three harvest dates.

Description	No. plants	Protein Av. %	Lignin Av. %	Cellulose digestibility
		Harvested May 27, 1960		
Nonheading	4	14.8	3.3	---
Emerging to late boot	4	14.4	3.2	---
		Harvested June 2, 1960		
Nonheading	5	14.4	4.1	58.7
Fully emerged	5	11.0	3.9	56.2
		Harvested June 20, 1960		
Nonheading	5	11.1	4.2	53.4
Fully emerged to in bloom	5	7.2	5.4	35.6

Preservation of Fresh Forage

A number of experiments were carried out on a laboratory scale to test the effect of some volatile chemicals in preserving freshly cut forage stored in air-tight containers. The efficiency of these preservatives was determined mainly by the dry matter loss occurring during the period of storage. The greatest loss occurred in untreated forage and the smallest loss when propylene oxide was used as the preservative. A number of other chemicals gave intermediate results. One experiment is summarized in Table 2. Propylene oxide, in the concentrations used, was found to be highly lethal to fungi and to cause a great reduction in the number of bacteria.

Table 2. Summary of experiment with freshly cut alfalfa stored 3 months in 1-pint Mason jars. Size of aliquot 160 g.

Treatment and results	Final pH	Percent loss of dry matter
Untreated, strong odor with some seepage	6.1	14.8
0.5 ml. propylene oxide, some fermentation odor	6.0	4.4
2.0 ml. propylene oxide, no odor	6.0	- 0.6
5 ml. ethyl ether, no odor	6.0	1.8
0.16 g. chlorine dioxide, fresh odor	6.1	3.0
0.33 g. chlorine dioxide, odor of ClO_2	5.9	2.1
0.67 g. chlorine dioxide, same	5.7	1.2
0.42 g. chlorine, not much odor	5.3	1.8
0.84 g. chlorine, same	4.9	0.9

Climate at State College

In State College, Pennsylvania monthly air temperatures were near normal during 7 months in 1960. March and December mean temperatures were 10 degrees below normal and during April, July and October 4 degrees below normal. Precipitation was 8.01 inches below normal for the year but field growth was seriously limited only during late July and August. Precipitation was about 3 inches above normal during May and September. Snow cover, scattered and light in January and early February, was followed by snow depths of 9 to 13 inches until the end of March. In December, 10 inches accumulated in the first week and remained until late February 1961. Soil temperatures all year remained above freezing 16 inches deep beneath a bluegrass sod, and a 4-inch depth freezing occurred only during January, February, March and December.

Soil moisture measurements indicated that 12 to 18 percent of total available water was present beneath a clipped bluegrass sod during May and late July. In August moisture was less than 10 percent at depths from 2 to 16 inches, and during other months it ranged from 25 percent to field capacity. The last killing freeze in the spring occurred April 18 with 28°F. and the first freeze in the fall was on October 25. This provided 190 freeze-free days for alfalfa, Ladino white and red clovers as well as for orchardgrass, bromegrass and timothy.

Climate Studies

(Co-operative with Ten States in the Northeast - NE-29)

During 1960 daily observations of precipitation, air and soil temperatures, soil moisture, and other environmental conditions affecting plant growth were forwarded monthly to the Pasture Laboratory where they were summarized on a bi-weekly basis. Such summaries were then forwarded the following month to each of the co-operating stations.

Departures from normal precipitation and normal mean temperatures, soil temperatures observed at the 4-inch depth beneath a Kentucky bluegrass sod and also soil moistures at depths of 4 and 8 inches were summarized.

Precipitation in all states was above normal for February, May and September and below normal for January, March, June, August, November and December. During April, July and October precipitation was near normal except in State College, Pa. where it was below normal in April and August and also in Ithaca, New York where it was below normal during July. During July, precipitation was above normal at New Brunswick, New Jersey, Kingston, R.I., Storrs, Conn. and Northwood, N.H., and also in October at Burlington, Vt.

Air temperatures in 1960, were generally above normal during February, April and November but were below normal in March, July, October and December. During January, May, June and August and September, temperatures in most states were near normal except during May where, from Ithaca, New York southward, temperatures were cooler than normal and in states northward, temperatures were above normal.

Last killing frosts (assumed 28°F. air temperature) in the spring and first similar fall temperatures were summarized for the ten states. The number of days between the above freezing temperatures were appreciably greater in central and southern parts of the region, Conn., Pa., and W. Va., 193, 190, 198 days respectively, than in the northern parts, Orono, Maine, Burlington, Vt. and Kingston, R.I. - 153, 176, and 176 days.

Mean soil temperatures 4 inches beneath a grass sod, were warmest 70-75°F. during July and August and were coldest 29-31°F. during January, February and March. Soils during the summer were appreciably cooler at Ithaca, New York than at other states and in the winter they were warmer at College Park, Maryland.

Soil moistures at a 4-inch depth, as reported by five stations indicated favorable conditions for growth except during periods in late July and August when soil moistures were limiting at State College, Pa. and Ithaca, New York.

Legume and Grass Seedling Establishment

In April 1960 observations were made on the legumes and grasses seeded in 1959 (1959 Annual Report, pages 24 and 25). Considerable heaving had occurred in the two seedings of alfalfa and Ladino clover made in June and July. Heaving of birdsfoot and the grasses was only slight. In earlier seedings of alfalfa and Ladino clover, heaving was slight while with birdsfoot and the grasses, heaving was not evident. Generally plants from earlier seedings of all species had a more extensive root system than later seedings.

In 1960 four seedings of three legumes (alfalfa, Ladino clover, birdsfoot trefoil) and three grasses (brome, Reed canary, orchard) were made April 13 and 29, May 25 and June 17. In the early April seeding, emergence was poorest, 30 to 60 percent. This apparently was caused by a light rain three days after seeding, which resulted in a crust on the soil surface that hindered emergence. The late April seeding provided highest total emergence, 40 to 76 percent. During this period the distribution of rainfall was even but soil temperatures were lower, about 55°F, and these probably caused the slower emergence rate of 13 to 24 days to attain the maximum number of seedlings.

In both May and June, percent emergence was similar. During these periods rainfall was good and higher soil temperatures, 65-70°F., probably accounted for the shorter emergence time of 6 to 12 days.

Production and Persistence of Perennial Grasses Receiving Different Rates of Nitrogen Fertilizer when Harvested for Hay at Varying Stages of Maturity

(Co-operative with 9 Northeastern States)

In this regional trial by states under NE-29 R & M funds, a technique was required to measure food reserves of the experimental plants by means other than chemical methods to measure sugar components. Results of previous trials at the Pasture Research Laboratory indicated that during recovery of grasses following clipping, the sugars (food reserves) found in leaf sheathes near ground level rapidly decreased and following two or three weeks recovery growth, sugars began to increase. After 4 weeks growth, the initial concentration of sugars was attained. Other studies indicated that nitrogen fertilization of grass also decreased food reserves similarly to clipping. From these studies it was felt that the stored energy (food reserves) was utilized primarily for replacement of leaf material after cutting, and that nitrogen fertilizer also used sugars by stimulating the initiation and development of new leaves.

Because at most state stations facilities for chemical analyses were not readily available for assignment to this experiment, a simpler biological method for measuring carbohydrate reserves was suggested. The method included taking 5 replicates of small samples about 2-3 inches in diameter of the clipped sod to a soil depth of approximately 2 inches. These sod samples were placed in cottage cheese cartons, surrounded with fine soil, and then firmed and moistened with a dilute solution of potassium nitrate. After all tillers were cut to heights of 1 1/2 to 2 inches, the cartons were placed in a dark cabinet for re-growth at temperatures of 70-75°F. After a week or 10-days, new growth from each tiller was cut at the previous height and oven dried. The number of tillers from which such etiolated growth was taken was recorded.

From weights of dry matter the weight per tiller was calculated. Using this for a base to compare recoveries, it was not necessary to obtain exactly uniform areas of grass samples.

For a preliminary test, samples were taken from orchardgrass, bromegrass, and Reed canarygrass grown as greenhouse plots with four levels of reserves obtained by using treatments including high and low rates of nitrogen fertilizer followed by clipping and no-clipping. The dry matter per tiller produced in darkness was determined from these samples of orchardgrass, bromegrass and Reed canarygrass.

Species responded differently to the clipping and fertilizer treatments. In orchardgrass the use of both the high rate of nitrogen and clipping reduced recovery growth, whereas with Reed canarygrass and brome, recovery growth was slightly greater at the high rate of nitrogen. Recovery growth of Reed canarygrass generally continued longer and produced more total dry matter per tiller than did orchardgrass and bromegrass. (Table 3).

Table 3. Mean recovery capacity milligrams per tiller of five samples of three grasses that received previous management treatments.

Species	Nitrogen-clipping treatments*			
	+N +C	+N -C	-N +C	-N -C
Orchardgrass	2.2	3.5	7.0	8.4
Bromegrass	3.5	7.8	4.2	5.6
Reed canarygrass	10.8	16.5	9.3	12.7

* +N = 100 #N/Acre -N = 25 #N/Acre +C = clipped -N = not clipped

During spring and summer samples were taken from small field plots of orchardgrass. Half of these were clipped once in early April when reproductive heads were beginning to form. An additional treatment was the application of high and low rates of nitrogen to half of each of the above areas. As field plants developed, samples were taken at the vegetative, pre-boot, head-expanded, and full-bloom stages. Samples from each plot were taken again after 28 days recovery following the previous cutting.

Recovery-capacity of plants decreased as the plants progressed from vegetative toward the full-bloom stage. Reduction of recovery in the dark on plots that were clipped in April and those that received nitrogen fertilization was most pronounced early in the season. The trend towards equalization of recovery from harvesting and fertilizer treatments may have been influenced by lack of soil moisture during the summer. Variability between samples indicated a need for an improved technique of sampling under field conditions. Such work is planned for 1961.

The biological measure of reserves (recovery-capacity) has been used primarily on grasses but preliminary trials on alfalfa suggest that it may also be used with legumes. Alfalfa was sampled at different stages of maturity. After potting and cutting off tops 2 inches above the soil the plants were allowed to recover in the dark. Recovery-capacities for early bud, full-bud and full-bloom stages were 7.0, 12.2 and 14.3 milligrams per tiller respectively.

Physiological Studies on Root-Spreading Alfalfa

In 1960 investigations initiated on the non-genetic factors affecting the root-spreading habit of alfalfa were primarily exploratory in nature. Based on these investigations specific trials will be conducted in 1961 to determine effects of environmental factors and management treatments on the root-spreading habit. The preliminary studies included: I. Harvesting at three stages of maturity:—Three harvest treatments, at the early-bud, full-bud and quarter-bloom stages were superimposed on nine replications in the root-spreading breeding nursery.

The nursery had been established in the spring of 1959 and percent of plants showing the root-spreading habit was determined prior to the differential harvest treatments in the spring of 1960. The percent of root-spreading plants was determined again in the fall of 1960 when it had increased 5 percent but there was no difference among the three harvest treatments. Percent root-spreading and the degree of spreading will be determined again in the spring of 1961. The same harvest schedule will be followed for at least one more year.

II. Screening for root-spreading habits:—During the summer 52 plants were selected from the nursery described above. The selection was based on degree of root-spreading, general vigor, recovery after defoliation, and resistance to disease. Several cuttings from each plant were established in pots in the greenhouse. Further screening to select clones of varying degree of root-spreading and vigor is now in progress. It is anticipated that about a dozen clones will be maintained and used in greenhouse trials to investigate the effects of photo period and temperatures on the root-spreading habit.

Grafting, non-root-spreading tops on root-spreading roots indicated that adventitious buds were produced on such roots, but that no adventitious buds were formed on the reciprocals. Further grafts are planned to study the effect of vigorous and non-vigorous tops on the root-spreading character.

III. Factors affecting rooting of alfalfa cuttings:—Factors affecting the certainty of successful rooting of alfalfa cuttings are unknown. Here and elsewhere consistent rooting has not been obtained even when material from the same source has been used. Additional trials were therefore conducted.

On cuttings of root-spreading alfalfa, lengths of axillary branches on the cutting and the branch position on the main stem, whether from top, middle or bottom were observed. Results from 1500 cuttings indicated a direct relationship between the percent rooting and the total length of an axillary branch on the cutting. Percentages of well-rooted cuttings with axillary branches less than 1 inch, 1 to 1 1/2 inches and greater than 1 1/2 inches were 21, 46 and 79 respectively. Cuttings whether taken from the lower, middle or upper portions of branches, were similar when the cuttings had been characterized relative to lengths of axillary branches. Only a limited number of cuttings with axillary sub-branches longer than one inch were obtained from basal portions of the main branches.

Growth of Ladino Clover Seedlings in Association with Orchardgrass

In previous studies (1959 Annual Report, pages 25-26), growth of Ladino white clover was less when it was grown in nutrient solution in which orchardgrass was also growing. Studies reported below were conducted to determine whether excessive use of potash by the grass may have limited growth of the legume. Use of the gravel culture technique permitted periodic flushing of clover with a nutrient solution that drained back to a small carboy for reflushing. In these trials, Pilgrim Ladino white clover was seeded in a pot of gravel and 7 of these plants were transplanted into each nutrient-gravel pot when cotyledons on the seedlings were fully expanded. Three replicate pots were used for each nutrient concentration-treatment.

In 1959 results indicated that clover growth was better when accompanying orchardgrass was clipped to reduce its growth and also when the complete nutrient solution was renewed weekly to provide and maintain the standard level of nutrient elements more nearly. Based on these results, additional trials were warranted to measure responses of clover supplied different concentrations of nutrients and particularly potassium. Three treatment-conditions were used in combination with 4 concentrations of potash. These may be summarily presented as: (a) K always available, (b) K absent one day and (c) K absent 3 days. Under each of the above, four geometric increases in concentrations of potash as well as Ca, N, Mg, P and S were provided while minor elements were the same in each, 4 times the lowest concentration in (a) above. The four levels of K included 25, 50, 100 and 200 ppm. and under the (a) treatment two additional higher concentrations of K at 300 and 400 ppm. were also used. Growth at 300 ppm. was poor and at 400 ppm. plants were dying after 3 weeks.

After 36 days growth during February and March under greenhouse temperatures of 70°F. with mazda lights to provide a 16-hour day, the clover plants were harvested and the dry weights of the tops and roots were determined. These dry weights coincided with expectations; growth was greatest in (a) nutrients including K were continuously available, growth decreased in (b) and (c) where only K was missing for 1- and 3-day periods, respectively, each week.

Comparisons of dry matter produced under different concentrations of potash indicate that growth increased from 25 to 100 ppm., was followed by a slight decrease at 200 and a marked decrease at 300 ppm. This occurred under all frequencies of K availability, (a), (b), and (c), and suggested no marked interaction with K concentrations in the nutrient solution.

During May and June another trial was conducted providing further information on growth responses of the clover when only the concentration of K varied from 0 to 300 ppm. and all other elements, (Ca, Mg, P, N, etc.) were supplied in a concentration similar to the 100 ppm. K used in (a) above that previously had provided best growth. Results of this trial indicate increased growth at 0, 25, and 50 ppm. of K but with further increase of K to 100, 200 and 300 ppm. the dry matter production remained constant. This suggests that elements other than K limited growth or that interactions with light and increased temperatures also increased the use of elements differently under the greenhouse conditions present in May and June when compared to those in February and March.

Concurrently with the above, a trial was conducted to measure any differential responses to K when it was supplied as KNO_3 or K_2SO_4. Concentrations of K at 25, 50, 100, 200 and 300 ppm. in the nutrient solutions were used to compare resulting growth when K was supplied either as the nitrate or the sulfate. The weights of clover growth produced indicate that differences were small except at the extremes of 25 and 300 ppm. At the lowest concentration of K, K from the nitrate source provided about 1/4 more growth than the sulfate but at the highest concentration, growth from the nitrate source of K was 1/4 less than the sulfate.

These trials indicate that for clover either KNO_3 or K_2SO_4 may be used as the source of K but at the low concentration insufficient nitrate may have limited growth whereas at higher concentrations excessive nitrate may have decreased dry matter production during the cloudy winter months of February and March.

Uniformity Trial in Growth Chamber Using Red Clover Seedlings

To measure growth responses of plants to specific climatic factors, chambers may be used in which environments are controlled by special equipment. Factors such as air and soil temperatures, humidity, and the intensity and quality of light can be controlled generally within a chamber but due to limited space and a reduced number of pots used in a chamber as well as location of the pots, variations between microclimates may occur within a chamber.

In this trial effects of positional variation due to light and temperature on plant growth responses and also comparisons of plant responses were measured under 2 general temperature-light treatments - (1) alternating (60-80°F.) versus constant (70°F.) and (2) three qualities of light at constant temperatures (70°F.).

In each of four chambers 16 warm-white slimline lamps and 4 daylight lamps were used. In addition chambers #1 and #2 included 14 additional warm-white lamps, #3 included 14 additional experimental-red lamps using an arsenic phosphor and #4 included 14 experimental-red lamps using a germanium phosphor. Both of these reds had peak emissions at about 640 $m\mu$.

Seedlings of Pennscott red clover were used in these trials. The seed was germinated on moist blotters in Petri dishes from which uniform seedlings with primary roots 1/8 inch long were selected for planting. Seven were planted equally spaced in well-firmed fertile soil in 4-inch glazed pots, which were placed on a greenhouse bench for one week's growth. During this time the emerging seedlings were observed frequently and those which were off-type (either too small or too large) were replaced by other germinating seeds. Records were made of all such changes.

After a week in the greenhouse the cotyledons were fully expanded and the pots were moved into the growth chambers at mean temperatures of 70°F. and supplied with a 16-hour day length. After 35 days' growth the plants were harvested and total dry weights of plant material in each pot were obtained.

Statistical analysis of weights of tops indicates that in chambers 1 and 2 the means, at 3 locations (corners, sides, and centers) differed at the 5 percent level of significance. Differences between corners and sides in chambers 1 and 2 exceeded 0.14 grams $LSD_{.05}$. Yield differences between chamber 1 (alternating) and 2 (constant) were small. Apparently alternating temperatures did not add to positional variation in chamber 1.

In chambers 1 and 2 differences in radiant energy may have been a primary contributor to positional variation. Analysis of covariance with light intensity as the independent variable and dry weight as the dependent variable indicated that when adjustments at different locations were made to remove effects of radiant energy, the differences in dry matter yields between different locations were non-significant.

In chambers 3 and 4 approximately 90% of the total radiant energy came from the red lamps from which emission is in a narrow spectral band. This may be related to the non-significant differences that were obtained between locations in chambers 3 and 4. The apparent uniformity in chamber 4, suggests that quality of light may have reduced positional variation. It may also have resulted from the limited energy provided in other wave lengths. Further investigations are needed to determine a satisfactory combination of fluorescent lamps to provide the best quality of light.

Differences between coefficients of variation for locations within chambers were small. In general the corners and centers were less variable than the sides. Coefficients of variation for chambers 1, 2, 3 and 4 were 12.71, 12.79, 14.33 and 10.85 percent respectively. The extent to which variation within a chamber can be reduced may be limited, but as is shown in this investigation, positional variation may be statistically removed from the estimates of treatment effects by utilizing center, side, and corner locations as blocks, or by utilizing the variation of an independent variable in covariance analyses.

Influence of Temperature, Soil Type, Time, and Rate of Phosphorus Fertilization on the Phosphorus Absorbed by an Anion Exchange Resin and by Red Clover Plants

A short-term nutrient uptake experiment was conducted in the growth chambers to evaluate the release of phosphorus from two acid soil types (Morrison loam, pH = 5.5 and Red Bay fine sandy loam, pH 4.7) of different origin to an anion exchange resin (Dowex 21K) and to red clover plants as influenced by two temperatures (60° + 75°F.), three dates of harvest (11, 18, 25 days), and three rates of phosphorus application (0, 100 and 400 ppm P). The experimental technique was a modification of the TVA short-term nutrient uptake procedure in that P-deficient seedlings contained in open-bottomed 12 oz. cottage cheese cartons were placed onto 100 grams of each soil treatment contained in 12 oz. cottage cheese cartons.

Twenty-five grams of moist soil were thoroughly mixed with 25 grams of moist anion exchange resin and incubated at each temperature. A 10-gram sample of soil and resin was taken at each date of harvest from each treatment.

Anion-exchange resin absorbed phosphorus was determined by normal colorimetric means. One replicate of the plant sample was analyzed for total phosphorus.

Plant growth was best at the higher temperature, and highest rate of phosphorus application. The red clover growth was similar in both soils though slightly better on the Morrison loam. Severe manganese toxicity was noted in the experiment.

Root growth in the soil was affected very little by soil type, whereas temperature had a large effect on root growth in the soil. The ratio of weights of roots in soil at the high rate compared to the check was 5.1 at 60°F., and 5.4 at 75°F. thus indicating a similar relative effect of phosphorus on root growth at the two temperatures.

The variation in top weight of red clover produced could be accounted for on the basis of root development in the soil. Soil phosphorus was deficient (high P fixation losses) at both temperatures. Improved root growth occurred as a response to improved phosphorus nutrition.

Analysis of plant tops revealed that all plants were extremely phosphorus deficient.

The anion exchange resin (Dowex 21K) absorbed more phosphorus from the soil than did red clover. The greatest absorption of phosphorus by the resin occurred at the first harvest and lower temperature. The amount of phosphorus absorbed by the resin became less with each successive harvest, thus indicating loss of phosphorus from the resin to the soil fixation complex. More phosphorus was absorbed by the resin from Morrison loam than from Red Bay fine sandy loam. Resin absorbed phosphorus can be correlated with increases in plant growth as were increases of resin absorbed phosphorus related to rates of phosphorus application.

Some Preliminary Studies on Re-establishment of Ladino Clover in Existing Grass Stands

A. Effect of grass root sods on the growth of Ladino clover seedlings:— Soil plus roots from the center of pots of Saratoga bromegrass, Lincoln bromegrass, S-37 orchardgrass, Potomac orchardgrass, Common timothy and Climax timothy were seeded to Pilgrim Ladino clover. The clover seedlings were then watered with nutrient solution and allowed to grow for six weeks at which time they were harvested and dry weight of tops determined. Ladino clover was seeded into normal greenhouse soil as a check or a comparison.

The average dry weights of Ladino produced per container (4 replicates) were as follows: Saratoga brome, 44.0 mgms.; Climax timothy, 61.0 mgms.; Potomac orchardgrass, 62.0 mgms.; Common timothy, 71.5 mgms.; Lincoln brome, 74.5 mgms.; and S-37 orchardgrass, 76.3 mgms.; and the control, 100.5 mgms. The low production was associated with low light intensity conditions in the greenhouse, as well as small quantities of soil (60 grams) used in each container.

Though these studies are preliminary, they indicate that the decaying roots of certain grass species will have more effect on the growth of Ladino clover seedlings than will others. These studies may be expanded in the coming year.

B. Effect of segregated root systems on the establishment of Ladino clover in grass stands:—The effect of seeding Ladino clover in fresh soil in separate glass tumblers in the centers of well-established grass pots was beneficial only in the case of Lincoln bromegrass, Potomac orchardgrass, and Common timothy in a preliminary trial. The effect of light competition was of primary importance though apparently segregation of root systems resulted in higher K and Ca contents of Ladino.

A technique is needed to separate quantitatively the effects of competition for light, moisture, and nutrients and their interactions in legume-grass associations.

C. Effect of solution from surface of orchardgrass roots on the germination and growth of Ladino clover:—Whatman #1 filter paper was firmly placed against the solid mat of Potomac orchardgrass roots growing along the inside of a gallon, glazed pot. The soil containing the orchardgrass was saturated with water prior to the experiment. It was hoped that the filter paper would act as a wick to absorb substances released by the root mat. These substances would then flow by capillarity to the soil surface where evaporation of the water would concentrate any root exudate. A total of 2 trials was conducted at each of 4 and 6-day soil-root mat exposures. The exposed filter papers were air dried and separated into the top third, and the bottom two-thirds. The sections of paper were then placed in Petri dishes and moistened with dilute nutrient solution. Twenty-five Ladino clover seeds were placed on the moist paper, and allowed to germinate and grow in the dark for 4 or 5 days at room temperature, or 20°C., respectively. The results indicated the presence of a substance(s) on the top filter paper which would affect the germination and growth of the Ladino clover seedlings. However, great variation in time of germination of the Ladino seeds tended to make the results highly variable and thus unreliable.

Pre-germinating the Ladino clover seedlings and preventing direct exposures of the filter paper to sunlight are two modifications which should improve the reliability of the results obtained. With these improvements, the technique appears to have some promise as a tool in evaluating root interactions between species.

REPORTS OF R. AND M. COOPERATIVE RESEARCH

Title: PROJECT NE-13 - THE MECHANIZATION OF FORAGE CROP HARVESTING, PROCESSING, STORING AND FEEDING

Leader: E. C. Schneider, Chairman, Regional Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations, A.E.R.D. and S.E.S.D., A.R.S. (U.S.D.A.).

RESULTS:

1. Harvesting

Laboratory experiments have shown that mechanical bruising of pre-ensiled forage had a marked effect on final quality of the silage. Silage from bruised forage is characterized by low pH, high lactic acid and low butyric acid contents.

Study continued on the behavior of tractor tires in legume harvesting. Comparison of performance of new tires and smooth tires, indicates significantly greater damage from smooth tires. However, both kinds inflicted significant damage when compared with the control plots. Relating performance to a coefficient of traction (ratio of drawbar pull to actual weight on rear wheels) showed that, as the coefficient of traction increased, the degree of plant damage increased, and in many instances by a significant amount. Results this year indicate weight combined with slippage to be more damaging than weight alone.

The energy requirement for impact cutting was found to be a function of knife velocity and can be represented closely by a quadratic regression equation. Energy values leveled off for knife velocities above about 6000 ft. per min. for oats and alfalfa but remained higher than the shear cutting energy value.

Flail harvesters with "cup" shape knives and "L" shape knives were compared with the standard mower for harvesting hay. The flail harvester employing the "cup" shape knife removed more material from the stubble than the standard mower at speeds from 2 to 8 MPH. Material removed from the stubble by the "L" shape knives was in general less than that by the standard mower and decreased rapidly as travel speed was increased. Cutting yield with both knife shapes decreased as rotor speed decreased. The material raked and baled after cutting with the flail harvesters was dependent on particle size. The crop recovered was greatest when flail cut at slower rotor speeds and higher travel speeds. Harvest yield was higher with the "cup" shape knife than the "L" shape knife and harvest yield of all flail cut hay was lower than mower cut hay.

Field losses from baling and chopping hay were from 7-12 percent with small differences between the two systems. Losses from specific operations and components indicate that the combined losses of mowing, conditioning, and raking (6.0-9.0 percent) exceed the losses of either baling (1.4-4.0 percent) or chopping (2.0-6.0 percent).

2. Processing

Heated air drying of short bales loaded at random into wagons was studied. Success depended on control of bale density with dry weight densities of 4 to 6 lbs. per cu. ft. recommended for moisture contents of about 40 percent. With heated air recirculation in a four-wagon system, 42 lbs. of water were removed per gallon of fuel oil.

Studies of the recirculation of part of the exhaust air from a heated air wagon drying system showed the following: When 70 percent of the air was recirculated and the heat input was constant, drying rates and efficiencies were increased, especially during the later stages of drying. When a constant heated air temperature was maintained, drying rates were decreased slightly in the early stages of drying, but efficiencies were increased markedly at all times. Recirculation can be used for the full drying time to improve the drying efficiency and yet not appreciably increase the drying time when a heated air temperature limit controls the process.

Drying progress prediction equations were previously developed from results of tests using freshly harvested chopped alfalfa. Additional tests were made using alfalfa at various moisture contents to enable the equations to be adjusted for variability in moisture content. These results have not been completely analyzed, but the tests have been completed.

In a study of infrared drying of forage, 10 lbs. per min. of fresh chopped forage lost about 1.85 lbs. of water per minute during a two minute exposure with a heat requirement of 1,770 BTU's per lb. of water removed.

Fairly stable extruded hay pellets of approximately 1 3/4" diameter were made utilizing a tapered die section of Teflon. Pressures required varied from 2,400 psi to 4,000 psi as contrasted with pressures as high as 6,800 psi required previously with tapered steel dies.

Study was initiated in 1959 on the handling, drying, and storage of hay wafers. Durability of wafers was found to be dependent on the type of crop wafered and its moisture content at time of wafering. Crops wafered successfully include pure legumes and high legume grass mixtures. Wafers with good qualities were made at moisture contents ranging from 10 to 25 percent. Bulk densities of wafers in storage ranged from 10 to 20 lbs. per cu. ft., depending on moisture content and loose material. Trash content of wafers in storage ranged upwards to 30 percent depending on extent of handling. The safe moisture content of wafers for storage appears to be 14 percent or less.

3. Storing

In a study of handling and unheated air drying of short hay bales with random distribution in the mow, the capacity of the storage loft at completion of unheated air drying was 6.92 lbs. per cu. ft. and the dry weight density was 5.87 lbs. per cu. ft. Wall pressures for random bale storage were calculated assuming a uniformly distributed loading throughout a depth of 12 feet. Under these conditions, side wall pressures were about 35 lbs. per sq. ft. However, impact during random loading of high moisture short bales can exceed the wall strength of many older storages and reinforcement will be necessary in such cases.

High moisture orchardgrass silages stored in bunker silos with and without covers were compared. Approximate total loss from the covered silo was 19 percent and that from the uncovered silo was 37 percent. Over 10 percent of this difference was due to gaseous loss and more than 5 percent to seepage. The cost of plastic covers for bunker type silos is more than offset by the value of the increase of well preserved silage. In self-feeding silos, up to 16 percent of the silage was rejected because of higher moisture and lower quality silage next to the floor.

Laboratory scale tests were continued for the third season on common silo sections and surface treatments as related to adequate sealing and handling properties of haylage. Moving and static sidewall frictions were evaluated under ambient (70°F.) and frozen (-10°F.) conditions for 60 individual storage tests. The primary evaluation of materials and surfaces was in terms of resulting forage quality and further supported preliminary indications (1958 and 1959) of a range from excellent to very ineffective for materials ranging from steel to wood.

Permeability determination of test silo materials and treatments was made for air, O_2 and CO_2. Test procedures provided for statistical analysis and correlation with actual storage performance tests. High correlation was demonstrated between subjective evaluations of forage quality and objective evaluations in terms of pH.

4. Feeding

In the work with semi-automatic conveyor feeding of dairy cows in stanchions, a baled hay metering device was developed to the point where it showed that it could be satisfactorily incorporated in the conveyor feeding system. A 16 mm. color movie of this feeding system was released for use on a loan basis from the Vermont Film Library. Teflon sheet lining of silo unloader parts and chutes proved effective in improving the anti-stick, anti-friction and anti-corrosion characteristics of these parts.

In Washington, a semi-automatic trench silo unloader has been developed that has a capacity of 125 lbs. per min. of corn or short cut grass silage.

The most successful control device for the self-feeder silo consists of an eight-spoke wheel in combination with a fixed baffle. The primary advantage of this device is that contact with the silage is continuous, the load is never released.

Work has been completed on a silo unloader and auger bunk feeder automation. This includes an electronic device controlling the entire feeding system. Work has also been completed on the multi-purpose wagon used for dry lot feeding and a zero pasture program, hauling silage from chopper to silo and as a conventional wagon bed.

A self-feeder barn for curing, storing, and self-feeding chopped hay was constructed. It utilizes supplemental heat for drying. The barn is 20 feet wide and 33 feet long in 11 foot modulus with an "A" frame drying duct in the center. Distribution and initial filling are critical and drying was uneven because of poor distribution.

The use of a conveyor to reduce the carrying of chopped hay to hay chutes when removing chopped hay from the mow saved only 3.6 min. per feeding of a 50-cow dairy. Without the conveyor it took 11.1 min. per feeding to remove hay from the mow.

Further testing of the mow unloader experimental unit substantiated its satisfactory performance in chopped hay. Previous work was with 3 inch theoretical cut unsettled hay. This year's tests included 3 and 6 inch theoretical cut and settled bulk. (Maximum settled depth 9 feet). Delivery rates for the 9 inch auger unit at 36 RPM range from 480 to 540 lbs. per hr. This is considered too low although the consistency is desirable for possible time clock control.

Coefficients of friction were determined and analyzed for movement of fibrous material (forage) over various test unit surfaces. These data each represent 160 tests. Complete statistical analysis and tabulated coefficients are available. These data correlate very significantly with sidewall friction data of actual storage unit tests.

USEFULNESS OF FINDINGS:

A regional bulletin on hay conditioners based on data obtained from this project was published this year. This bulletin will help farmers select equipment best suited to their needs.

A manuscript has been completed describing the construction and use of a multi-purpose wagon for hauling chopped forage, self-feeding and other uses. This information will aid the farmer in reducing operational costs.

Knowledge obtained from studies on the effect of mechanical bruising of silage may provide better understanding of the silage preservation process. Since bruising also contributes to higher than normal densities, less storage volume may be required, thereby, reducing the farmer's capital investment.

Data obtained on flail harvesters with "cup" shaped or "L" shaped knives indicate excessive crop loss in raking and baling of hay so cut, making this method inefficient even though the hay generally dries faster than hay crushed with a smooth roll crusher. This information may provide a basis for an attempt to alter the flail harvester to reduce field losses.

Mechanical field loss data indicate that losses from hay chopping are not appreciably greater than losses from baling, and further, that losses from total systems involving either may exceed ten percent. This information provides for more realistic evaluation of harvesting procedures and may promote steps for reducing these losses.

Tractor tire performance and legume regrowth information obtained should be of value to manufacturers of tractor and implement tires. Farm managers should also benefit from this knowledge by being able to plan farming practices that will minimize the damage inflicted by traffic. Plant pathologists may find the information valuable when studying disease problems and the retention of a stand of legumes over a longer period of time.

Information and mathematical expressions obtained from experimental drying tests are useful in the understanding of the drying process of deep bed materials. They enable designers to design controls and systems with efficiency.

If hay bales are short (16 to 20 inches) and within a density range of 4 to 6 lbs. per cubic foot, the drying performance for either wagon or mow drying, when random loaded, was satisfactory, leading to quality hay production while at the same time reducing labor as a result of the use of mechanical loading devices in the field and mow.

Preliminary results on hay pelleting show the possibility of reduced power requirements as a result of improved die design and materials.

Data obtained about permeability of silo structures materials combined with actual storage performance provide for prediction of the allowable limits of permeabilities of materials for maximum silage quality.

Friction data obtained of forage on silo wall surfaces provide a basis for understanding the behavior of forage mass during placement and settling and are of particular importance in understanding the motion involved in bottom unloading.

The use of plastic covers for horizontal silos offers a means for reducing storage losses up to 50 percent and at a cost more than offset by the increase in silage preserved.

The automation of a mechanical silage handling system for beef cattle has greatly reduced chore time for feeding.

The use of a conveyor to carry chopped hay from the mow to the hay chute saves 1/3 of the time to remove hay from the mow by hand. Complete mechanization of this chore is necessary to gain substantial time and labor savings.

The auger type mow unloader for chopped hay promises to provide the automation link between mechanical harvesting and automatic feeding. Two major machinery manufacturers have expressed interest in it.

By installation of conveyor feeding systems for dairy cows in stanchions, time, labor and travel can be reduced. The amounts are measurable but vary with the installation. The system developed in the project does not readily lend itself to construction on the farm. It should be made commercially available by industry. Some industry interest has been evident.

WORK PLANNED FOR NEXT YEAR:

A proposed revision of the master project entitled, "Studies of the Physical Properties, Behavior and Forms of Forage as Related to Engineering Application" has been submitted and if accepted will become effective July 1, 1961. The revised master project orients the research along more fundamental approaches to the engineering problems with forages and new contributing project proposals reflect this change.

Title: PROJECT NEM-22 - FACILITATING THE MARKETING OF SEEDS THROUGH IMPROVED TESTING PROCEDURES

Leader: J. L. Newcomer, Chairman, Regional Technical Committee

Cooperators: Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Geneva and Ithaca), Pennsylvania, and Rhode Island Agricultural Experiment Stations, F.C.R.B., V.O.R.B., and S.E.S.D., A.R.S., U.S.D.A., and B.S.B., A.M.S., U.S.D.A.

In the growth chambers very satisfactory differences could be induced between southern and northern types of alfalfa by growing them under a 12-hour photoperiod and temperatures of 80°F. during the light period and 40°F. during the dark period. The following combinations of fluorescent tubes were used both with and without incandescent bulbs: white, blue and gold, red and green. White fluorescent tubes appeared to be as effective as any of the other tubes in producing differences between types of alfalfa. The use of incandescent bulbs tended to increase the difference that developed. Without bulbs, the stems of 27-day-old southern plants were 5.28 times as long as those of northern plants and with bulbs 6.03 times as long.

By using a temperature of 75°F. during the light period and 50°F. during the dark period, plants of Empire birdsfoot trefoil could be distinguished from plants of Viking or European three weeks after they were planted. With this temperature and 12 hours of light per day from white fluorescent tubes and incandescent bulbs, European plants developed stems twice as long as those of Empire. Only 15 percent of the European plants were prostrate as compared with 96 percent for Empire. Under this treatment, Viking tended to be less upright and had shorter stems than common European. All varieties tended to have fewer stems when incandescent bulbs were used.

With red clover as well as with alfalfa and birdsfoot trefoil, efforts are being made to produce blooming in a short period of time. If this can be done, plants can be classified as to length of stem before blooming, date of blooming, and color of flowers. By using long photoperiods and high intensity light, partly supplied by incandescent bulbs, a large percent of the plants have blossomed. Ways are being sought of causing more plants to bloom early. High night temperature was found necessary for early blooming in red clover. Four varieties of red clover were grown for six weeks with a day temperature of 88°F. and 18 hours of light per day, supplied by white fluorescent tubes and incandescent bulbs. When a night temperature of 60°F. was used, only 1.8 percent of the plants bloomed, but with a night temperature of 70°F., 21.4 percent of the plants bloomed.

One approach to the problem of achieving early blooming has been to spray seedlings with chemicals and expose them to different light treatments. So far this has not improved blooming, but has induced other interesting results. Duraset and an experimental chemical called B.O. 93 have produced 1 to 9 leaflets per leaf. Varieties varied considerably in percent of plants affected in this way, with Chesapeake and Kenland showing the most abnormalities and Dollard the least. Dollard had only 1/3 as many abnormal plants as Chesapeake or Kenland.

Dollard also has very few leaf markings compared with other varieties. It usually has markings on fewer than 10 percent of the plants, while other varieties have markings on 60 percent or more. To use this feature for variety testing, plants should show leaf markings soon after seeding. Conditions that favor blooming also favor early development of leaf markings. Dollard can easily be distinguished from other varieties three weeks after being planted.

Long photoperiods with part of the light from blue fluorescent tubes favor the growth of Climax timothy as compared with Essex or Commercial. With long days and blue lights, Climax was 1/3 taller than the other two types. The same daylength without blue light produced Climax plants only 5 percent longer than Essex or Commercial.

When timothy plants were grown in the greenhouse for five weeks, Essex plants developed significantly fewer tillers than Climax or Commercial. Keeping two-week-old seedlings at 39°F. for 10 days decreased tillering in Essex by 40 percent, but did not decrease tillering in Climax or Commercial timothy.

Spraying timothy seedlings with two applications of gibberellin at 10 ppm increased the height of the plants by 1/3, but varieties did not differ greatly in response. By growing timothy seedlings for 6 weeks under fluorescent lights with photoperiods of 20 hours, two or three plants per flat headed. However, very few plants headed even by the tenth week. Cold treatments are being used in an effort to get more of them to head.

In orchardgrass, the number of tillers was greatly influenced by the environment. Pennlate developed fewer tillers than the earlier varieties. Placing 2-week-old seedlings of three varieties of orchardgrass in a cold chamber at 39°F. for 6 days uniformly decreased tillering by 25 percent. Tillering in orchardgrass was also affected by the temperature and the type of light. More tillers were produced at 70°F. than at 80°F. Fewer tillers were produced when incandescent bulbs were used than when they were not used.

The alfalfa experiments that were seeded in 1959 were evaluated at all five field locations. New plantings of the row experiment to study the effect of different cutting dates in the fall were made at Maine, Maryland, Pennsylvania, and New York. Data compiled from the field plantings for four states showed that the greatest differences between varieties were in flower color and plant type in the fall. Fall observations in 1959 on the 1959 spaced plants showed

that Vernal and Narragansett plants were more prostrate than DuPuits or Williamsburg. Vernal had an average plant type score 46 percent larger than DuPuits, showing it to be much more prostrate. Observations on the same seedings in the fall of 1960 showed little difference between varieties in Pennsylvania, but considerable difference in New York and Rhode Island. The plant type score for DuPuits was only 1/3 as large as for Vernal at Rhode Island. Observations in the spring of 1960 showed that DuPuits and Williamsburg tended to be upright and Narragansett and Vernal semi-prostrate. Differences between varieties were less in the spring than in the fall. Plant height followed the same trend as plant type. In the fall of 1960 Narragansett and Vernal were 88 percent as tall as DuPuits and Williamsburg at Pennsylvania, but only 45 and 47 percent as tall as DuPuits and Williamsburg at New York and Rhode Island. Differences between varieties were greater in 1959 than in 1960 at Pennsylvania, but greater at New York in 1960.

At all locations stem diameter was greatest for DuPuits and small for Narragansett and Vernal. DuPuits at all locations had a stem diameter 20 percent larger than Vernal.

The date of blooming was earliest for DuPuits and latest for Williamsburg, with the average for all locations 3 days earlier.

Flower color can be used to distinguish yellow-flowered and purple-flowered varieties. In the purple-flowered varieties, DuPuits had more of the deep reddish purple flowers than Williamsburg, averaging 4.7 percent and 3.4 percent respectively.

Leaf color did not differ greatly or consistently among locations.

In the cutting date experiment, observations in the fall of 1959 showed differences among varieties, both at Pennsylvania and New York. The later the plants were cut in the fall, the more prostrate they became. In Maryland and Pennsylvania in 1960, there was little difference among varieties or cutting dates. In New York the plant type score was 30 percent higher for Vernal than for Williamsburg. The later the plants were cut in New York, the more prostrate they became.

Plant height responded to cutting date similarly to plant type. In 1960 varieties or cutting dates differed little at Maryland or Pennsylvania. In New York the early cutting was three times as tall as the late cutting and Williamsburg was twice as tall as Vernal.

USEFULNESS OF FINDINGS:

A test has been developed for birdsfoot trefoil that takes only three weeks to complete. It can identify off-type plants in Empire and European birdsfoot trefoil and results can be obtained fast enought to prevent planting of mislabeled seed in the field.

A test to detect off-type Dollard red clover plants can also be completed in three weeks and mislabeled lots can be identified in time to forestall planting them in the field.

Knowledge has been gained on factors that affect blooming of red clover, alfalfa, and birdsfoot trefoil. Further progress in this phase of the work may be expected.

Field experiments have developed better criteria for evaluating field plantings. Cutting date experiments have helped to determine when to cut alfalfa in the fall to obtain the best differences at each location.

WORK PLANNED FOR NEXT YEAR:

In the growth chambers plants will again be grown under different combinations of light quality, photoperiod, and temperature. Desirable combinations of day and night temperatures to bring out varietal differences will be determined for forage crop species under study. The temperature and light requirements for blooming in alfalfa, red clover, and birdsfoot trefoil will be studied. Hormone and sugar sprays on seedlings will be used to try to hasten blooming.

Further studies will be conducted with cold treatments of seeds and seedlings of timothy and orchardgrass to induce differential tillering and heading of varieties.

Chemicals that shorten stems of floricultural crops are available. These and others will be used on varieties of forage crops to see if there is a differential varietal response to chemicals. Effects of these chemicals under different environmental conditions will also be studied. In the field, authentic stock and synthetic mixtures of types and varieties of alfalfa seeds will be planted to check the accuracy of field, greenhouse, and growth chamber techniques. Varieties of alfalfa such as Williamsburg, DuPuits, Caliverde, and Vernal will be mixed by persons not participating in the testing. These seed lots will be subjected to the best field, laboratory, greenhouse and growth chamber tests available. They will be planted in the field at three or four locations in the Northeast Region in a design similar to the present field plantings. The best known methods of distinguishing varieties in the field will be used and the results will be compared with the greenhouse and growth chamber results as a test of their accuracy and their reliability.

Title: PROJECT NE-24 - THE NUTRITIVE EVALUATION OF FORAGES

Leader: B. R. Poulton, Chairman Regional Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations; A.H.R.D., S.E.S.D. and U. S. Regional Pasture Research Laboratory, A.R.S., U.S.D.A.

Among the many factors known to influence the nutritive value of forages, the following received special emphasis during the past year by this regional project: (1) cutting date and growth stage (Maine, Maryland, New Hampshire, New York, Pennsylvania, Vermont, and Dairy Cattle Branch A.R.S.), (2) nitrogen fertilization (Delaware, Maine, New Hampshire, New Jersey, Pennsylvania and Rhode Island), (3) method of preservation (New Jersey, New York, Pennsylvania), (4) geographical location of crop within a state (New York, Vermont) and (5) forage varieties within a species (Maryland, New Hampshire, New York).

In addition to studying quantitative effects of these factors on the nutritive value of forages considerable effort was also expended during the year in the study of: (1) metabolism of forage nitrogen (Delaware), (2) the utilization of pure grasses and legumes through in vivo rumen studies (Massachusetts), (3) relationship of in vitro cellulose fermentation to in vivo digestible energy or dry matter values (West Virginia, New Jersey, Maine), (4) correlation of nutritive value index of forages to in vitro cellulose fermentation, gas production, and in vivo dry matter loss (West Virginia), (5) effect of treatment of forage with chlorine dioxide, chlorine, and propylene oxide (all in gaseous form) on in vitro digestion and dry matter loss in storage (U. S. Regional Pasture Research Laboratory), (6) development of feed fractionation methods for predicting nutritive value of forage (Dairy Cattle Branch A.R.S., Regional Pasture Research Laboratory), and (7) production responses of dairy cows to specific forages (Maine, Maryland, Vermont).

Data obtained from the contributing projects this year again emphasized the effect of date of harvest on nutritive value. During the year, harvest date influence was studied using alfalfa, orchardgrass, birdsfoot trefoil, and timothy. The regression of dry matter digestibility on date of harvest for Climax timothy (Maine) cut at weekly intervals throughout the growing season was found to fit the equation $Y = 84.9 - 0.48 X$ where Y is equal to dry matter digestibility and X is equal to the number of days from May 17 to harvest date. The slope of this regression is nearly identical with that found for a large number of forages studied in New York. Data for other grasses and legumes also show decreases of dry matter digestibility of approximately 0.5% per day. Limited data available indicated that acceptability of forages is also markedly influenced by date of harvest. Three years' data on alfalfa bromegrass (Vermont) indicate that dairy cows on all forage rations will

respond to early-cut forage (June 5) with an average increase of 13 pounds of 4% milk in daily production over late-cut forage (July 15). Average daily dry matter consumption in these trials was 26 pounds on the early-cut forage and 17 pounds on the late-cut forage. Several stations (New York, Pennsylvania, West Virginia) have combined digestibility and acceptability data to obtain a nutritive value index for forages. Limited studies on aftermath forages (Maine, Maryland) indicate that although digestibility is adversely affected by delayed harvest the effects are not nearly so marked as they are in first-cut forage.

Studies this year (Delaware) on the metabolism of nitrogen contained in nitrogen-fertilized hays indicate rather consistent animal utilization of forage nitrogen independent of level of nitrogen fertilization. In the data obtained by Pennsylvania nitrogen-fertilized grasses appeared inferior in acceptability by sheep to legume-grass mixtures; however, results of a similar comparison using nitrogen-fertilized aftermath grasses plus concentrates with dairy cows (Maine) did not show this trend.

The form in which forage is stored and fed is known to affect its nutritive value under certain conditions. Maryland studies indicate that when all other conditions were fixed, pelleted hay was consumed in greater amounts and gave higher daily gains than similar forage when fed long. Observations made at the New York station indicated that forage fed long or chopped remained relatively constant in digestibility regardless of level of intake.

Vermont and New York confirmed their previous findings that hays harvested at various locations within a state but on the same date were approximately equal in nutritive value.

The nutritive value of varieties within a forage species has been studied (New Hampshire, New York). New York reported that the rate of decline in nutritive value of Essex timothy was considerably less than that of Common timothy due primarily to the superior acceptability of the Essex variety. Differences between varieties of other forage species were not so marked.

Several stations have continued their work to develop a reliable *in vitro* method of forage evaluation (West Virginia, New Jersey, Massachusetts). Correlation studies between *in vitro* cellulose fermentation and *in vivo* digestible energy or digestible dry matter were carried out using forages furnished by various stations within the region (West Virginia). Correlations between .83 and .89 were obtained using various rumen innocula.

USEFULNESS OF FINDINGS:

Additional quantitative information between nutritive value of forage and date of harvest is making it possible to develop optimum cutting management recommendations for the Northeastern livestock farmer. The additional information being obtained on acceptability will make it possible to work out a nutritive index for forages which will include nutrient content, nutrient digestibility and acceptability.

Studies on the nitrogen metabolism of forages grown under high levels of nitrogen fertilization will enable economists to determine more accurately optimum levels of use for nitrogen fertilizer. Results of work on nutritive value of forage varieties within a species will aid the plant geneticist in evaluating and selecting genetic material while at the same time furnishing information for planning forage programs for Northeast livestock farms.

Most of the states in the Northeast are attempting to offer a reasonably accurate forage testing service program to livestock farmers. A pressing need exists for the development of a laboratory (in vitro) technique which is both accurate and less expensive and involved than the present proximate analysis approach.

WORK PLANNED FOR NEXT YEAR:

The work planned for next year will be a continuation of that in progress. Special emphasis will be given to (1) measurements of acceptability of various specific forages, (2) enlargement of basic knowledge of factors affecting acceptability of forages, (3) development of an accurate, economical, in vitro forage analysis technique that can be used in extension forage testing programs, (4) expansion of knowledge on the relationships between nutritive value of forage and level of nitrogen fertilization, (5) development of more quantitative data on date of harvest and nutritive value and an assessment of variety variations within forage species and (6) continuing examination of interactions between methods of harvesting and storing forages and nutritive value.

Title: PROJECT NE-28 - BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST.

Leader: G. M. Dunn, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Delaware, Maine, Maryland, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations; F.C.R.B. and S.E.S.D., A.R.S., U.S.D.A., and A.S.T.A.

RESULTS:

Research was conducted during 1960 on breeding and evaluation of alfalfa and timothy at the following states: Maine, Connecticut, Rhode Island, New York, New Jersey and Pennsylvania. The breeding materials included the most promising selections which have been made in these species for the past several years. Evaluations were obtained for polycross progenies and new synthetics of alfalfa, and for parental clones and polycross progenies of timothy.

Several superior alfalfa selections have now been identified. These selections offer real promise for further improvement of this valuable species.

The timothy selections are particularly interesting. They varied considerably in maturity, dry matter content, and seasonal distribution of yield. These factors may significantly influence forage quality.

Trials were established in 1960 to evaluate 5 new alfalfa synthetics (in 7 states), 7 bromegrass synthetics (in 5 states), and 7 orchardgrass synthetics (in 5 states). Two or more associations and managements were planned for each species.

Various hybrid and synthetic combinations of alfalfa clones were produced in California for future regional trials to establish breeding principles for this species. Polycross and synthetic seed was produced from selected clones of bromegrass and orchardgrass.

Three publications were made in 1960 on methods of breeding and evaluation for alfalfa, bromegrass and orchardgrass.

USEFULNESS OF FINDINGS:

Information obtained in 1960 will be of value in determining the adaptation, quality, and productivity of alfalfa and timothy breeding materials, and of potential varieties which may be constituted from them.

The hybrid and synthetic combinations of alfalfa already produced or planned under NE-28, will provide an opportunity to establish principles for forage improvement which are inadequate at the present time, largely because of the time and expense involved in producing the necessary combinations of selected clones. Regional support for this research is therefore considered essential and most appropriate.

WORK PLANNED FOR NEXT YEAR:

Data will be obtained for the alfalfa, bromegrass, and orchardgrass tests established in 1960, and for a few of the alfalfa and timothy tests established in 1956-1958. New alfalfa trials will be established at 6 locations in 1961 to obtain information on principles of breeding for this species.

Additional alfalfa hybrids and synthetics will be produced in New York and California. Seed increases of bromegrass and orchardgrass selections will be continued.

Title: PROJECT NE-29 - MANAGEMENT AND PRODUCTIVITY OF PERENNIAL GRASSES

Leader: R. C. Wakefield, Chairman, Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations; Forage and Range Res. Br. and S.E.S.D., A.R.S., U.S.D.A.

RESULTS:

The project is designed, in part, to investigate the relationship between physiological development and cutting management of grasses in order to determine practices most conducive to stand maintenance and the production of high quality forage.

Experimental treatments were initiated by eight stations on uniform plantings of perennial grasses as follows:

State Experiment Station	Grasses
Connecticut	Potomac orchard, S-37 orchard, Reed canary and Lincoln brome.
Maine	Climax timothy.
Maryland	Saratoga brome, Potomac orchard, Pennlate orchard, and Reed canary.
New Jersey	Potomac orchard and Reed canary.
New York	Lincoln brome, Saratoga brome, Potomac orchard, Pennlate orchard, and Reed canary.
Pennsylvania	Potomac orchard, Pennlate orchard, Reed canary, and Climax timothy.
Rhode Island	Saratoga brome, Potomac orchard, and Climax timothy.
West Virginia	Potomac orchard and Climax timothy.

First growth was removed at four stages ranging from pre-jointing through past bloom. New York and Rhode Island treatments included an additional stage of cutting within this range. Season yields of dry matter generally followed a pattern established at the first cutting and gave a varying response among species and locations. Highest yields were most often obtained at the early bloom or past bloom stages. Harvesting at the pasture stage (pre-jointing) or early jointing usually resulted in lowest yields with the late boot stage being intermediate. Some exceptions were noted but were not consistent for a given species or location. Reed canarygrass cut at the late boot stage at Maryland and Pennsylvania gave yields comparable with later stages. Pennlate orchardgrass at New York, Climax timothy at Maine and Saratoga bromegrass at Maryland performed relatively well when cut at the pre-jointing stage. Cutting at the early stages of maturity resulted in a re-distribution of yields by markedly increasing the first aftermath growth.

The aftermath growth was cut once at high and low stubble heights. These treatments were designed either to preserve or remove active growing points or meristematic tissue of tillers. Measurement of the subsequent growth gave no substantial increase in dry matter for either treatment. A small but significant increase in yield was noted with Climax timothy at Maine. Data at New York indicated that Pennlate orchardgrass benefited from high cutting. The yields of Saratoga bromegrass at new York and Rhode Island were increased by high cutting but only when this followed a first harvest at the jointing stage where shoot apices were removed. The sacrifice in yield associated with a high cut, which generally exceeded two-tenths of a ton, was not easily recovered at subsequent cuttings. Season yields were not significantly different for the two cutting heights for any species with the exception of Potomac orchardgrass at Maryland where low cutting was beneficial. The vigor of bromegrass was maintained more successfully by high cutting at New York and Rhode Island. Several stations noted that a combination of low cutting with a high nitrogen fertilizer level reduced stands of orchardgrass, bromegrass and timothy.

Cutting management treatments were evaluated at high and low levels of nitrogen fertilization. Treatment effects were generally comparable although the magnitude of yield response differed significantly. Interaction of nitrogen level with stage of first harvest was occasionally significant for one or more species. This was most often found with Potomac orchardgrass. However, the response of any given growth stage of Potomac to nitrogen level was not consistent among locations.

Physiological responses of grasses to treatments were evaluated by means of measurement of growth, vigor, persistence of plants in the fall. Further data will be obtained in the spring to determine effects on over-wintering. Substantial data were accumulated on growth characteristics of grasses in relation to treatments and weather conditions, including soil moisture. These data provided investigators with a better basic understanding of the several grasses under a variety of growing conditions.

Darkroom studies were carried out to evaluate the "recovery potential" of selected species following spring harvest treatments by measuring etiolated growth. This technique was followed as a possible method of evaluating the carbohydrate reserves responsible for regrowth of active tillers. Greatest regrowth occurred at the pre-jointing and late growth stages with bromegrass at New York; at the early heading stage with orchardgrass at West Virginia; at the late bloom stage of Reed canarygrass at Maryland; at the pre-jointing stages and late growth stages at New Jersey; and at the late maturing stages with timothy at Rhode Island. Nitrogen appeared to have little effect on "recovery potential" following the first cutting. Nitrogen and high cutting favored regrowth of bromegrass at later harvests at New York, while low nitrogen gave best response on fall samples at Rhode Island.

All stations reported degrees of variability of growth response from dug samples placed in the darkness. Variation often gave results of doubtful value or precluded significance in an analysis of data. Some refinement of technique appeared to be necessary.

USEFULNESS OF FINDINGS:

Management studies of perennial grasses represent a largely unexplored area of forage crops research. Information is being accumulated on the growth response of four species to differential defoliation at two nitrogen levels. Data on growth characteristics are providing a basic understanding of the grasses under a variety of growing conditions.

Results indicate that grass management is rather complex and depends to a considerable extent on factors of management, weather conditions, and physiological condition of the plant. Species appear to respond to individual management practices. Spring management largely determined the magnitude of yields for the year. An early cutting prior to jointing offers promise of shifting a heavy aftermath to a later, more favorable weather period for hay production. Nitrogen fertilizer was shown to have a substantial effect on increasing growth.

WORK PLANNED FOR NEXT YEAR:

Cutting management treatments will be continued with minor modifications in procedure. Residual effects of previous treatments as well as accumulative effects on persistence and seasonal aftermath growth will be determined. Data will be collected in accordance with recommendations of a subcommittee on procedure.

Title: PROJECT NE-43 - PROFITABILITY OF ALTERNATIVE FORAGE SYSTEMS FOR NORTHEAST DAIRY FARMS

Leader: John W. Carncross, Chairman, Regional Technical Committee

Cooperators: The 12 Northeastern Agricultural Experiment Stations, S.E.S.D. and F.E.R.D., A.R.S., U.S.D.A.

The work under this project for 1960 centered around three subcommittees. Operating under subcommittee one were Connecticut and Rhode Island. The project of both of these states was "Economics of Selecting Forage Crop Rotations for Dairy Farms."

Linear programming method incorporating data of annual forage crop yields is being used to determine the least cost feed combination for dairy herds. The yields under different combinations of forages and rotations are being obtained from experimental plots. Fertilizer applications and crop rotations are being investigated. For individual crops, the Ladino-grass mixture of alfalfa in a rotation with corn silage resulted in the lowest unit cost to get yields of two to three tons per acre of hay equivalents. For higher yields corn silage with heavy fertilizer application offered the best alternative.

Subcommittee two with the states and their projects were as follows: Delaware - "Comparative Costs of Different Hay Drying Systems"; Maryland - "An Analysis of Forage Storage on Dairy Farms"; Massachusetts - "Economics of Storing Forage in Horizontal Silos"; New Jersey - "Economics of Production and Storage of Forage on High Cost Dairy Farms".

Hay drying costs and returns were analyzed for the different methods of drying found in use on farms. Delaware has published a three-year finding in Technical Bulletin 334. In cooperation with other departments of the experiment station, the quality and quantity advantage of artificial drying of hay was carefully measured and analyzed. Maryland studied the inputs and outputs of drying hay with mow driers using forced air and no heat, mow driers with heat, the platform drier and wagon driers. Primary emphasis was on the first three methods as very few used the wagon type hot air hay drier. New Jersey on the other hand emphasized the practices and cost of operating wagon type heated air hay driers. These three states are now combining their findings into a REGIONAL PUBLICATION on hay drying which is expected to be ready for the press early in 1961.

Time and motion studies were made on filling operations for horizontal silos. The time required for unloading a ton of silage for horizontal silos was only one fourth of that for unloading for tower silos. No conclusive difference in time for feeding was found between horizontal and tower silos. The percent of spoilage in horizontal silos over tower silos was the most important factor in determining the economic disadvantage of horizontal silos.

Subcommittee three included New York with a project entitled - "The Economics of Different Patterns of Forage Production and Use on Dairy Farms in the Plateau and Oneida-Mohawk Regions of New York"; West Virginia - "Input-Output Relationship of Forage Production on Dairy Farms in the Appalachian Valley." In addition some collaborative data are to be furnished by the states of Maryland, Vermont, and New Jersey.

An extensive study was made of the forage production practices and botanical content of hay meadows. Legume content in hay meadows which averaged about three and one half years of age had dropped off sharply after the first year. Both upland meadows and valley meadows showed increases of legume content with increase in pH from 5 to 6.9. The pH level was found to be directly related not only to the legume content but also to crop yields, milk per cow and to

labor income. There was little or no relation of the rate of lime application to legume plant content which emphasizes that seed mixtures for a particular feed should be determined by the pH rather than the lime application. There are many factors in balancing the forage production program with the farm setup. Farms vary as measured by acres and number of cows. One study was done in the southern part of the region where, on 56 dairy farms, forage was being produced on 38 different soil types. Forage rotation practice varied greatly. On deeper soils, which were subject to overflow, corn is grown year after year. On shallow soils a cultivated forage crop was rarely grown for two successive years.

The complexity of forage production in the region involves the kind of forage, and difference in soil type, rainfall, drainage, and elevation. These factors and others determine the economics of forage production and in turn the economic returns from dairy farming.

USEFULNESS OF FINDINGS:

In 1959 the total cash income from dairy products for the states covered by this regional project was more than one billion dollars. This was 77 percent higher than the cash income of the next nearest commodity group. The cost of forage is the largest single item in the cost of producing milk. The magnitude of dairy farming in this northeast region and the importance of forage production makes imperative continuous regional research such as in this project. The availability of this information is critical at the present time as northeast dairymen are in a cost-price squeeze. Dairymen are eager to use technical innovations when they are economically feasible. They can use the results of research from this project to make sound economic decisions in relation to their forage systems.

WORK PLANNED FOR NEXT YEAR:

Research will continue in the year ahead in the collection of new data, analysis of data collected this past year, and publication of studies.

PASTURE RESEARCH AT STATE STATIONS

CONNECTICUT (STORRS)

Title: ALFALFA EXPERIMENTS

Leaders: B. A. Brown and R. A. Peters

(a) Fertilization: As in 1959, (1959 Annual Report, pages 45 to 47) banding superphosphate (46 percent) at 300 pounds per acre caused greater development of alfalfa roots in each of three 6" layers of very phosphorus deficient soil than mixing the same amount with the upper 6" or with all of the soil. The yields of each of five cuttings were also greater where the superphosphate was banded.

In the 1959 experiment dolomitic hydrated lime (35-25) at 6000 pounds per acre was mixed with all of the soil. ($CaCO_3$ requirement of soil was 9000 pounds). In 1960, omitting the lime from the middle 6" or middle and bottom 6" of the 18" total depth resulted in more root development at those levels and in greater top growth than when all three 6" layers were limed. Although P, K and B were mixed with all of the soil it is suspected that a lesser availability of P, B or Mn may have been the cause of the reduced growth where all of the soil was heavily limed.

In field experiments and on farms, inadequate liming is frequently thought to be the cause for poor results with alfalfa. In a recent greenhouse experiment with strongly acid soil (pH 5.2), dolomitic hydrated lime at one-half, full and double the lime requirement produced quicker and greater reductions in acidity and larger yields of alfalfa than equivalent rates of dolomitic limestone. To bring the pH of the soil to 6.7 in three weeks required nearly three times as much limestone as hydrated lime. After nine months the limestone had not decreased the acidity as much as the hydrated lime.

On previously unlimed soil (GI4, pH 5.2) alfalfa seeded in 1958 had the same poor stands and yields in 1960 on all plots although the rates of dolomitic limestone varied from 2 to 6 tons per acre. In August 1960 the pH values of the upper 5" of soil ranged from 6.0 to 6.4.

Better results were obtained from a similar experiment seeded on another part of the same field in 1959 but again there were no differences in 1960 between dolomitic limestone rates varying from 2 to 8 tons per acre.

Less than half of the limestone applied in these experiments passed a 100 mesh sieve. In neither experiment did replacing one ton of limestone with

three-fourths ton of hydrated lime have any appreciable effects on the reactions of the soil or on the alfalfa.

On previously limed soil with a pre-treatment pH of 6.0 (P5) excellent stands and yields from a 1959 seeding of alfalfa were obtained in all cases with rates of dolomitic limestone varying from 1 to 16 tons per acre.

In previous field experiments on the same soil the effects of varying rates of dolomitic limestone did not become evident until the third year after seeding alfalfa. It is concluded that strongly acid soils should be limed with limestone, especially dolomitic limestone, at much higher rates or long before--perhaps two years--seeding alfalfa.

In several previous greenhouse and field experiments, seedling developments of alfalfa have been accelerated by banded or mixed-in superphosphate but yields at the early bloom stage did not vary appreciably. In a 4-year field experiment where the soil had a pre-treatment, available phosphorus level of "medium", no significant differences in yields were obtained from 0 to 720 pounds per acre of superphosphate (46 percent). Because of such results it is thought that superphosphate might well be applied liberally before seeding to hasten seedling establishment and omitted for several years thereafter or even for the entire life of a stand.

To test this supposition again, another field experiment was seeded in 1959 on soil with a "medium" level of available phosphorus. The pre-planting rates of superphosphate (46 percent) varied from 200 to 1600 pounds per acre. No more superphosphate will be added excepting on four of the eight 200-pound plots, where that treatment will be repeated annually.

The seedling growth was appreciably better on the highest rates of superphosphate but all yields in 1960 were uniformly high--over five tons of dry matter from two cuttings. Future results should be of interest.

(b) Varieties:

Many years of testing alfalfa varieties at this Station have shown that marked differences in stands and yields have not occurred in most cases until after the second or third harvest year. When appreciable differences have occurred, symptoms of wilt have been prevalent in the varieties with the poorest stands.

In 1960, a notable exception to this general result was recorded in the second harvest year. The Alfa, DuPuits, and NK 501 varieties had over 20% wilt and greatly reduced stands during the latter part of that season. In the same test, Atlantic, Narragansett, Vernal and several other varieties showed no symptoms of wilt and had good stands.

(c) Cutting Systems: In recent years a different philosophy has been advanced in regard to the frequency and time of harvesting alfalfa. In brief, this new plan is to plant one of the very vigorous, rapidly recovering types, fertilize beyond any possible danger of a deficiency, harvest without much regard to the long established principles, and reseed when the stand is thinned and unproductive, usually stated as after two or three harvest years.

There are several fallacies in this plan: (1) The vigorous, rapidly recovering types reduce their root reserves to low levels in less time than the "standard" varieties and under frequent, immature cutting systems soon exhaust their reserves to killing levels. (2) There are no kinds or amounts of fertilizers which will prevent the bad effects of very immature or other poorly timed harvesting. (3) Under a year of such drastic management, large yields will not be obtained in the second season, to say nothing of the third.

Some recent results with a 1958 seeding of DuPuits illustrate these statements. In 1959 all plots were cut on June 22nd when the alfalfa was approaching full bloom. The second cutting was made at the bud stage on half of the plots and at the one-fourth bloom stage on the other half. Each of four different dates of fall cutting was superimposed on five plots of "bud" stage and five plots of one-fourth bloom second cuttings.

In 1960 none of the "bud" stage cuts of 1959 had stands above 58 percent and that was where no fall harvest had been made. Where a fall cut was made, the best stand was only 38 percent. The corresponding values for the one-fourth bloom plots were 73 and 54 percent.

With no fall cuts the total yield of dry matter, including volunteer species, was 1100 pounds per acre less on the bud stage than on the one-fourth bloom plots of 1959. All the fall cuttings caused further marked decreases in yields.

Title: WEED CONTROL IN FORAGES

Leaders: R. A. Peters and H. C. Yokum

Work has continued on a study of the life history of yellow foxtail (Setaria glauca). A better understanding of the growth characteristics of this species will assist in determing control measures.

(1) Seed Germination: An inquiry into the effect of environment and seed morphology on the germination of yellow foxtail was started in 1958. Of many environmental treatments used, soaking seed in KNO_3 was most effective in breaking post-harvest dormancy. Comparing all treatments used, seed coat scarification was the most effective method of increasing germination. It was found that the caryopsis will germinate more readily once the lemma and palea are removed. This work suggests that lack of water uptake is at least one factor in the dormancy found in foxtail seed during the first few weeks following harvest.

Field grown plants were found to be prolific seed producers. Many uncrowded plants produced over 8000 seed heads per plant. Day length, not plant size, was found to control the time of seed head production. This short day response induces plants to set seed before the growing season is terminated.

(2) Growth Inhibitor in Yellow Foxtail: A study was begun to determine the possible occurrence of a germination and growth inhibitor in Setaria glauca. The experimental evidence indicated that foxtail produces a germination and growth inhibitor (s). Further studies were made to characterize the inhibitor.

It was concluded that the inhibitor is a small, non-protein, non-volatile, polar molecule. The inhibitor also appeared to be non-nitrogenous, non-alkaloid, and not easily ionized; the results with chromatograms indicated that Rf regions of strong inhibition are associated with high sugar concentrations.

(3) Competition Between Foxtail and Seedling Alfalfa: The marked competitive effect of foxtail on the alfalfa seedlings was indicated by a 60 percent decrease in yield when foxtail was grown in association with alfalfa. The foxtail was decreased only 25 percent when in association. Yields were increased by each increment of fertilizer except for alfalfa when grown in association. Inspection of the data giving the amount of K in the tissue shows a greater K content in the foxtail tissue in every instance except when alfalfa was growing alone at the high fertility level. These data are in line with the work of Drake, Vengris and Colby[1] on the relatively high uptake of K by plants having a low root cation exchange capacity. Of 21 grass species studied, these workers found foxtail to have the lowest cation exchange capacity (11.4 me/100 gm). The capacity of alfalfa roots was found to be four times as great. In the present experiment, when alfalfa was in competition with foxtail, K in the alfalfa decreased while increasing somewhat in the foxtail.

Fertility level had more effect on the percent K in the tissue in the alfalfa than it did in the foxtail. As the fertility level increased, the K percent in the alfalfa alone or in association increased while in the foxtail there was relatively little change. The percent K was actually somewhat higher in foxtail at the lower fertility level when growing in association. The nitrogen level probably limited foxtail yield, thus K utilization at the low fertility level. Alfalfa obtained the necessary nitrogen thru fixation.

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[1] Drake, Mack, Vengris, Jonas and Colby, William. Cation exchange capacity of plant roots. Soil Sci. 51: 139-147. 1951.

DELAWARE

Title: THE EFFECT OF FORM OF ROUGHAGE ON THE REPRODUCTIVE PERFORMANCE OF MARES

Leaders: J. H. Shropshire and W. H. Mitchell

Twenty Welch X Chincoteague ponies, all bred to the same stallion, were divided into two test groups. One group received nothing but baled hay for a period of 320 days and the other group received comparable hay in pelleted form. The hay used was largely alfalfa and red clover. While there was some variation in hay mixtures from month to month, the two groups of horses always received comparable hay -- the only difference being in form.

It is emphasized that this test involved hay only. Pellets were 3/4-inch in diameter and made from hay that passed a 1/2-inch screen in a hammermill. These results should not be interpreted as necessarily applying to pellets of a different size or of a different fineness of grind.

This work is still in the data analysis stage. Some of the more apparent results, however, are as follows:

1. The average live weight of mares fed pelleted hay was consistently greater over the 160-day pre- and post-parturition period than that of mares fed baled hay.

2. The average birth weight of foals was 74 pounds and the foals on pelleted hay were consistently heavier than the baled hay group over the 180-day period following birth. The average weight of foals at the end of the test was 409 pounds for the pellet group and 357 pounds for the baled hay group.

3. Pelleted hay was more efficient than baled hay in producing live weight gains of mares and foals. Part of the lower efficiency for baled hay could be attributed to leaf loss, rejection, and other wastes in feeding. A large part of the difference must be accounted for by other factors.

An overall comparison shows that 17.4 pounds of pellets were required to produce 1 pound gain in live weight; with baled hay, 22.2 pounds were required, or an increase in feed efficiency of 27.5 percent.

This increased efficiency more than compensates for the added costs associated with pelleting. For example:--

1 ton of baled hay @ $50.00 per ton	-- equivalent to --	1450 lbs. of pelleted hay @ $59.15 per ton

Total cost to the hay buyer would be $50.00 for the baled hay and $42.88 for hay pellets.

Title: IRRIGATION AND NITROGEN FERTILIZATION OF LADINO CLOVER, ALFALFA, BIRDSFOOT TREFOIL AND ORCHARDGRASS

Leader: W. H. Mitchell

Several forage crops were studied over a three-year period to measure the effect of supplemental water and nitrogen applications on their root and top growth. Ladino clover, alfalfa, orchardgrass and birdsfoot trefoil were each grown alone and each legume in association with orchardgrass. Each mixture was treated with 2 nitrogen and 4 irrigation levels. Nitrogen treatments were 0 and 150 pounds of nitrogen applied annually. Irrigation involved the application of water in 1-, 2-, and 4-inch quantities to obtain the same total amount of water annually. Comparisons were made with a control which received only natural rainfall. This rainfall amounted to 59%, 115%, and 98% of the longtime mean, during the growing season, for the years 1957, 1958, and 1959 respectively. Supplemental water was added in 1957 and 1959 at the rate of 8 and 4 inches per year.

Yield responses were measured by mechanically harvesting dry matter samples and by removing, annually, 6-inch root cores to a depth of 24 inches. Each root core was divided into 4-inch depths and each depth was analyzed for root weights and root adsorption of methylene blue. The adsorption of methylene blue per gram of dry root tissue was calculated and thereby provided a relative measure of root activity.

The most important findings of this work are as follows:

1. Alfalfa, without irrigation, outyielded all other species even when these were irrigated.

2. In only 1 year of the past 4 has irrigation resulted in significant yield increases.

3. In many cases the principal contribution of irrigation was better distribution of hay production over the growing season.

4. In terms of hay production 4 inches of water in a single application was never better than the same 4 inches in two 2-inch or four 1-inch applications.

5. Irrigation encouraged weed growth in all hay mixtures with the greatest increase in the trefoil mixtures and the least in those containing alfalfa.

6. Irrigation generally decreased the size of root systems regardless of the method of applying water.

7. Nitrogen applications decreased the size of root systems but increased their adsorption capacity.

8. Very significant increases in root activity occurred with increasing root depth while at the same time the dry weight of roots dropped sharply.

It is concluded that irrigation of alfalfa mixtures is not profitable in the Middletown area, because of lack of growth response during normal seasons and the relatively low frequency of drought so severe that irrigation responses are obtained.

Cost studies at the Hay Research Farm have shown that when irrigating 100 acres of land and applying a total of 8 inches of water the following costs are involved:

Ownership costs	$ 9.63 per acre	
Operating costs	7.91 per acre	
Total costs	$ 17.54 per acre	or $2.19 per acre inch of water

These values applied to the irrigation program at Middletown clearly show the practice to be uneconomical.

Year	Ownership Costs	Operating Costs	Water Applied	Yield Increase
1957	$ 9.63/acre	$ 7.91/acre	8 inches	2000 lbs.
1958	9.63	- - - - -	- - - - -	- - - - -
1959	9.63	- - - - -	- - - - -	- - - - -
1960	9.63	- - - - -	- - - - -	- - - - -
	$38.52	$ 7.91	8 inches	2000 lbs.

Total irrigation costs	$ 46.43
Cost of processing additional 1 ton of hay	17.08
Total cost of increased hay	$ 63.51
Value of increased hay	$ 50.00

These values might be different as other hays are substituted for alfalfa, but similar costs and returns would probably prevail.

Title: NITROGEN AND PHOSPHORUS FERTILIZATION OF GRASS - LEGUME MIXTURES

Leader: W. H. Mitchell

Four levels of nitrogen and phosphorus (0, 50, 100, 200 pounds of N and K_2O) have been applied to mixtures of alfalfa and several grasses (timothy, bromegrass, tall fescue, Reed canarygrass, orchardgrass). Plots were harvested with a sicklebar mower adjusted to cut at about 2" above the ground.

The results are similar to those found in previous years. A response to nitrogen fertilization was found only in those plots where the alfalfa component of the mixture was so small that it failed to supply adequate nitrogen for the associated grass.

No consistent response was noted to annual applications of phosphorus above the 50 pound level. When more than 50 pounds was used a notable increase in plant phosphorus resulted. Soil phosphorus also steadily increased with annual applications of over 50 pounds to the soil.

Timothy and bromegrass did not persist in appreciable quantities after the first 2 years of this study. Orchardgrass and tall fescue stands were reduced in the areas that received nitrogen at the rate of 100 and 200 pounds annually. The persistence of alfalfa was not lessened by the nitrogen treatments but in some cases the associated grasses were reduced by 90 percent.

MAINE

Title: FORAGE BREEDING AND VARIETY TESTING

Leader: C. R. Blackmon

Red clover: The performance of Lakeland and Dollard red clover continued to be superior to other varieties in both yield and resistance to anthracnose. Altaswede was most persistent from year to year in winter survival. Eight red clover varieties are currently going through the second winter at Orono, after which longevity evaluations should prove very valuable.

Alfalfa: DuPuits and Narragansett are the two top performing varieties. DuPuits has been outstanding in leaf spot and mildew resistance. A new variety test will be conducted in 1961 to include several recent varieties.

Orchardgrass: Twelve orchardgrass varieties were tested at Orono in 1960. The highest yielding varieties were Pennsylvania Medium, Pennlate, Potomac, Iowa No. 6, Iowa No. 1 and Kentucky Synthetic. Commercial was the lowest yielding variety. Kentucky Synthetic was the earliest maturing variety and Okaroa was the latest with eight days difference between them.

Smooth Brome: Lancaster bromegrass followed by Fischer, Saratoga and Wisconsin 55 were the highest yielding bromegrass varieties in 1960. Proper evaluation, however, must recognize maturity dates and brown leaf spot. Manchar was the earliest variety tested and had the least leaf spot. Lancaster and Lyon bromegrass matured latest -- about six days after Manchar.

Title: UPTAKE OF TOPDRESSED POTASSIUM AS AFFECTED BY TIMING, SPECIES AND SOIL TYPE

Leaders: C. S. Brown and P. N. Carpenter

A study of the effect of soil texture upon the recovery of topdressed potassium applied at different times throughout the season was initiated in 1960. Seedings were established at five field locations on soils ranging in texture from a Merrimac sandy loam to a Suffield silty clay loam. Split-plot comparisons of alfalfa vs. high-nitrogen timothy are being made, under a three-cut harvest system.

Concurrent greenhouse and laboratory studies are being conducted to determine potassium release, fixation and leaching characteristics of different horizons of each of the five field soils.

Title: RECOVERY OF NITROGEN TOPDRESSED IN FALL OR SPRING

Leaders: C. S. Brown and P. N. Carpenter

A long-term study of the yearly variability in the recovery of fertilizer nitrogen topdressed on bluegrass sod at various dates in the fall and spring is underway. Soil temperature and precipitation data are being obtained to correlate with nitrogen recovery. Urea and ammonium nitrate are the two nitrogen sources, applied at a constant rate of 150 lbs. N per acre.

Unusually heavy precipitation during October and November of 1959 (13.1 inches) resulted in very low recovery of nitrogen from fall-applied fertilizer, with little difference noted between carriers. Nitrogen recovery ranged from 9 percent for fertilizers topdressed on September 15 to 56 percent when fertilizers were withheld until the following April.

Title: MANAGEMENT OF ALFALFA MIXTURES

Leader: C. S. Brown

An experiment was initiated in the 1960 season to study the effect of frequency of harvest upon the survival and yield of legume components of alfalfa-trefoil and alfalfa-Ladino clover mixtures. Beginning in 1961, each of the two mixtures will be subjected to two cut, three-cut and four-cut systems. The interaction of cutting frequency and species competition will be determined by comparing legume component yields of the mixtures to the yields of check plots of the single legumes, Narragansett alfalfa, Mansfield trefoil, and Ladino clover.

Data obtained in 1960 substantiated previous results obtained with regard to the superior vigor of alfalfa in the seeding year under conditions of high fertility and lime. The 1960 results also indicated that Mansfield trefoil was distinctly superior to Ladino clover in seedling establishment under the drought conditions which prevailed. Brief summary data are presented below:

Seeded legume lbs./acre	Yield component	Dry matter tons/acre
Alfalfa (10)	Alfalfa	1.58
Ladino (2)	Ladino	0.25
Trefoil (8)	Trefoil	0.73
Alfalfa (5)	Alfalfa	1.34
+ Ladino (2)	Ladino	0.06
Alfalfa (5)	Alfalfa	1.26
+ Trefoil (8)	Trefoil	0.18

Title: NUTRITIVE VALUE OF GRASSES AS AFFECTED BY NITROGEN, DATE OF HARVEST, AND REGROWTH INTERVAL

Leaders: B. R. Poulton, M. J. Anderson, T. N. Millin, and R. C. Haven

A relatively pure stand of Climax timothy was harvested at eleven stages of maturity beginning on May 27 and at weekly intervals until August 5th. Conventional digestion studies were carried out. Analysis indicated a uniform decrease in crude protein, digestible energy, digestible dry matter, and T. D. N. from May to the July 22 cutting. The regression of dry matter digestibility on date of harvest was found to be linear. The regression equation was calculated to be $Y = 84.9 - 0.48X$ where Y is equal to dry matter digestibility and X is equal to the number of days after May 17 that the forage was harvested. On the basis of the nutritive values found, the estimated yields, and regrowth recovery, the most desirable date for first harvest of timothy in Orono, Maine appears to be between June 10 and June 17.

The acceptability of nitrogen-fertilized aftermath bromegrass hay was studied in a herd of 47 milking Guernseys. The bromegrass hay was cut August 13 (60 days after first cut) and was grown with 144 lbs. of nitrogen (72 lbs. on each crop). Concentrate and silage feeding were standardized, hay intake was found to be 17.1 pounds per cow during a 46-day period, while silage intake averaged 24.6 pounds and grain intake was 1 pound per three pounds of 4 percent F.C.M. Average daily milk production was 26.5 pounds per day. In a similar study with this same herd intake of grass-light legume mixed hay was 15.8 pounds per cow per day and daily milk production was 25.2 pounds per day.

Title: CHEMICAL COMPOSITION OF MAINE ROUGHAGES

Leaders: Bernie E. Plummer, Jr., A. S. Getchell, John A. Blease

A limited amount of work has been done on silage quality.

Work has been continued on the composition of three varieties of timothy cut at three different stages of maturity. Leaves and stems are separated and analyzed separately. The analysis includes moisture, protein, ether extract, crude fiber, ash, NFE, lignin, cellulose, and carbohydrates other than lignin and cellulose. The results on the 1960 samples have the same general composition as those reported for 1959. Data are being accumulated on the relative composition of early, medium, and late varieties of timothy cut June 10, June 25, and July 10. Information is also being accumulated on the difference in composition of leaves and stems of the three varieties cut at the three different dates and the changes in composition at different stages of maturity. This work will continue for three more years.

Title: HARVESTING PROBLEMS ASSOCIATED WITH HIGH YIELDING FORAGE

Leaders: R. J. Rowe and C. M. Milne

A study was begun in 1958 with the primary objective of determining the effect of intense fertilizing of forage crops on the functional requirements of harvesting machinery. Large area plots (totaling 20 acres) of timothy, alfalfa, red clover, and bromegrass were established. The grasses have been subjected to high nitrogen fertilization of varying intensities, and the legumes have been adequately limed and fertilized.

Experimental data have been obtained during the summers of 1959 and 1960. The effect of mechanical treatment and fertilization level on field drying rates has been measured. Measurements of dry matter losses and percent leaf losses have been made for various harvesting methods involving conventional mowing, raking, and baling, cutting and picking up with a flail harvester. The applicability of various machines for cutting lodged and tangled crops has been investigated. Results to date are preliminary.

MARYLAND

Title: FORAGE CROP VARIETY EVALUATION IN MARYLAND

Leaders: R. C. Leffel, N. A. Clark, and A. M. Decker

Alfalfa: Six varieties of alfalfa were evaluated at College Park and Trappe during their second years of harvest. The test at College Park included two fertility levels and two cutting managements. Interactions of varieties x fertility levels and varieties x locations were not significant; the interaction of varieties x cutting management was significant. Ranking of varieties was similar, however, whether each variety was cut at its own optimum cutting date or at the same date as all other varieties. DuPuits was the most productive variety.

Red Clover: Chesapeake red clover was superior to all other varieties evaluated at College Park during 1960 in forage yields and plant stands. Breeders and registered seed lots of Kenland red clover varied significantly.

White Clover: A variety test at College Park during 1960 included 11 entries. Strains superior for forage yields and plant stands included Pilgrim, Iowa Synthetic, Bohnert, and Gigante Lodigiano. Performance of M-1 (Willows) was good. La. S1, Vermont polyploid, S100, Kersey white, Denmark Synthetic, and a white clover from Germany were undesirable in this evaluation.

Bermudagrass: Variety tests have been reduced to one location in the Piedmont region of Maryland. The major portion of testing thus far has been confined to the Coastal Plain area. As was the case in other years and at other locations, Midland continues to be the most productive variety. Greenfield is only slightly less productive. It is considerably more susceptible to leaf diseases, however. Both of these varieties were substantially more productive than common Bermuda. These three are the only varieties tested that survived the winters of Piedmont Maryland.

Sudangrass, Pearl Millets, Johnsongrasses, Sorgrasses, Sorghum Almum, and Sorghum-Sudangrass Hybrids: In 1960 variety testing of these forages was continued at the Forage Research Farm near Ellicott City. Plants were harvested to simulate pasture conditions. Considerable variation occurred in the maturity dates of the Sudangrasses. Of the early maturing Sudangrasses, Tift and Piper were superior from the standpoint of production and leaf disease resistance. Greenleaf was less productive but showed considerable leaf disease resistance. Common Pearl Millet and Gahi No. 1 Pearl Millet were later maturing by a week than the Sudangrasses mentioned, but were as productive as the Sudangrasses and showed greater resistance to leaf diseases. The commercial Sorghum-Sudangrass hybrids ranked with the highest producing Sudangrasses and Pearl Millets and were comparable to the Pearl Millets in leaf disease resistance. The perennial sorghums which were established in 1959 were observed for winter survival in the spring of 1960. Fewer than five percent of the plants in any of the plots survived the winter. Rhizomes of several of the surviving plants were examined and found to be similar to Johnsongrass in appearance. Observations of these plots were then discontinued. Testing of the annual forage varieties which have been superior in the past two years will be continued to evaluate these plants further.

Title: RED CLOVER BREEDING INVESTIGATIONS

Leader: R. C. Leffel

Twenty-five clones, selected among 7,000 plants of a space-planted nursery for persistence, productiveness, and ease of vegetative propagation were utilized in a polycross nursery during 1960. The same 25 clones exhibited a range in degree of "pseudo-self-fertility" from 0.00 to 2.37 seeds per head and a range from high resistance to high susceptibility to powdery mildew prevalent in the greenhouse during most of the season. Future studies will

concern inheritance of "pseudo-self-fertility" and its possible use in breeding programs of red clover, and the isolation of lines resistant to powdery mildew.

Title: LADINO CLOVER BREEDING, DISEASE, AND INSECT INVESTIGATIONS

Leader: R. C. Leffel

Evaluation of a plant introduction nursery was continued in 1960. Most of the material has survived and reveals a great range in morphological characteristics. Studies concerning factors affecting persistence of Ladino clover were continued - all treatments including checks (no treatment) exhibited good stands at the end of the growing season. A number of clones showed relatively high "pseudo-self-fertility" and are being investigated for sterility allele segregation in the S_1 generation.

Title: RESPONSE OF ORCHARDGRASS TO VARIOUS RATES OF APPLYING POTASSIUM AND NITROGEN

Leader: C. B. Kresge

For the third consecutive year, the use of a two-to-one ratio of nitrogen to potash resulted in yield increases greater than those for any other ratio tested (1957 Annual Report, page 54). Maximum yield in 1960 was 4.27 tons of dry matter per acre from five cuttings of orchardgrass. The grass received an annual application of 200 pounds of nitrogen and 100 pounds of potash per acre. The check plot yielded 1.42 tons per acre. When the data from all three years were summarized and evaluated, it was concluded that: (1) Topdressings of 200 pounds of nitrogen and 100 pounds of potash per acre applied annually to orchardgrass resulted in the highest yield. Economically, somewhere between 150 and 200 pounds of nitrogen per acre might be best. (2) This combination of nitrogen and potash also resulted in the best percent recovery of nitrogen, phosphorus and potassium in the harvested forage. The percent recoveries in 1960 were 84, 71 and 212, respectively. The mining of soil potassium would lead one to consider a lower nitrogen to potash ratio, 1.5 to 1. (3) The potassium level in orchardgrass forage at which a significant decrease in yield from the maximum is obtained appears to be higher when the higher rates of nitrogen are used. This percent potassium was 2.68 for 200 and 400 pounds of nitrogen, and 2.15 for 50 and 100 pounds of nitrogen per acre.

Title: COMPARISON OF NITROGEN SOURCES ON ESTABLISHED BLUEGRASS SOD

Leader: C. B. Kresge

Urea-formaldehyde (75 percent), urea, $(NH_4)_2SO_4$, and NH_4NO_3 were topdressed at various rates on an established bluegrass pasture for two years (1957 Annual Report, page 55). Residual effects of these nitrogen carriers were evaluated in the third year. Yields were measured and total nitrogen was determined on plant samples from all plots. No differences in total yields (three years) existed among nitrogen sources applied at rates of 80, 80-80, and 160 pounds of nitrogen per acre per year. At the 160-160 pound rate, total yields of plots receiving NH_4NO_3 were greater than those topdressed with the other sources. Split applications of the more available nitrogen sources were favorable in a "wet" year but not in a "dry" year (1959 Annual Report, page 57). Urea-formaldehyde, supplemented with urea, produced the most uniform seasonal distribution of growth and its residual effect continued throughout the third year. Residual effects of urea, $(NH_4)_2SO_4$, and NH_4NO_3 were largely restricted to the first half of the third growing season. Although the percent protein of urea-formaldehyde-fertilized grass was less than that of bluegrass topdressed with other sources, the percentage was satisfactory for good quality forage. Urea and NH_4NO_3 performed best in respect to nitrogen recovery, while use of urea-formaldehyde resulted in the lowest recovery. Disregarding cost and at rates of nitrogen currently in use, urea-formaldehyde, urea, $(NH_4)_2SO_4$, and NH_4NO_3 can be used with equally satisfactory results in a long-range bluegrass pasture program, with two compensating qualifications: (1) that urea-formaldehyde need be supplied only once each year as compared to twice or more for more available sources, and (2) that the urea-formaldehyde be supplemented with about 25% of the nitrogen from a more available source.

Title: RESPONSE OF BERMUDAGRASS TO VARIOUS RATES OF POTASSIUM AND NITROGEN APPLICATION

Leaders: C. B. Kresge, A. M. Decker, and N. A. Clark

Various rates and ratios of nitrogen and potassium were topdressed in 1960 on an established Midland bermudagrass stand. The experimental plots are located at the supposedly northern limit of practical bermudagrass cultivation. Nitrogen rates of 0, 100, 200, 400, 600, and 800 pounds per acre were equally split and applied in late spring and after the first cutting. Potash at rates of 0, 50, 100, 200, 400, and 600 pounds per acre was topdressed in late spring. Yield data were taken four times during the growing season. The grass was cut when it reached a height of 8 to 10 inches. Bermudagrass samples from all plots were analyzed for nitrogen, phosphorus, and potassium content. Maximum yield (6.8 tons of dry matter per acre) was obtained with 400 pounds of nitrogen per acre. Very little response to potassium was noted.

The soil probably had sufficient potassium reserves to avoid deficiency. This experiment will continue for two or three years so that the nutrient balance required by bermudagrass can be properly evaluated. In subsequent years, the same rates of nitrogen will be split into four equal applications instead of two.

Title: TIME AND RATE OF POTASSIUM APPLICATION TO ALFALFA AND ALFALFA - ORCHARDGRASS

Leader: C. B. Kresge

Potassium at various rates was topdressed in single and split applications at five different times of the year (1957 Annual Report, page 55). Muriate of potash was applied in early spring and/or immediately after one or more of the four seasonal cuttings. The responses of alfalfa and an alfalfa-orchardgrass mixture to these additions were measured for three consecutive years. Each year the alfalfa was first cut in full bud, whereas subsequent cuttings were taken at the 1/10 to 1/4 bloom stage. Dry matter yields of the mixture exceeded those of the alfalfa by an average of one ton in three years (13.14 to 12.14 tons per acre). An annual application of 200 pounds of potash per acre was sufficient to meet the needs of both systems in producing maximum yields. The time of year or frequency of potassium applications was of little significance. The percent potassium in the alfalfa plant critical for maximum yield, varied from 1.75 to 2.00, the level being lower in the first two cuttings of the year than in the last two cuttings. The critical level for the alfalfa-orchardgrass mixture was slightly higher than that for alfalfa, but only in the first two cuttings.

Title: ALFALFA FERTILIZATION

Leader: John Axley

Fertilizer applications to alfalfa fields should be varied with soils. In general, soils could be divided into fixing and non-fixing groups. A single application of fertilizer can be applied any time during the year on soils that do not fix phosphorus and potash, whereas fixing soils give superior yields from divided applications during the growing season.

Alfalfa can be converted into a soil depleting crop by inadequate fertilizer applications. This happens when growth is stimulated with smaller quantities of fertilizer than are needed to maintain maximum production over a period of many years. Actually for the first few years, peak alfalfa production is often obtained in such a depletion program. This tendency of mature alfalfa

to deplete the soil and maintain yields leads some to believe that all is well. They do not realize that such soil will be even less fertile with respect to phosphorus and potassium than it was originally. That such conditions do occur has been verified by both alfalfa yields and analysis of plant tissue and alfalfa soils for phosphorus and potassium.

Title: INFLUENCE OF SOIL TEMPERATURE ON FORAGE GROWTH

Leaders: A. Morris Decker and N. H. MacLeod

During 1960 a pilot soil temperature controller was put into operation. It was found that controlled temperatures in the 70° - 100°F. range could be obtained in the field. Approximately one week was required for equilibrium to be obtained to a depth of four inches. Work has progressed beyond the pilot stage with design and installation of equipment with sufficient capacity for replicated 6 x 15 ft. plots at 3 temperature levels.

Title: EFFECTS OF IRRIGATION AND FERTILIZATION OF FIVE FORAGE SPECIES

Leader: A. Morris Decker

Forage yields were obtained for the third harvest year (1957 Annual Report, page 55). All of the Ladino clover plots and a few of the high nitrogen bluegrass plots were lost during 1959.

Yields ranged from 1.32 tons/acre for bluegrass with 100 lbs. of N to 5.82 tons/acre for Midland with 400 lbs. of N. Tall fescue and Midland yields were substantially increased with each increment of nitrogen and had only a small increase as a result of irrigation. Pounds of forage produced per pound of nitrogen were increased by the addition of water. Kentucky bluegrass yields were highest with 200 lbs. of N, lowest with 100 lbs. and intermediate with 400 lbs. The low yields from the high nitrogen treatment resulted from stand reduction. Irrigation of bluegrass resulted in only small yield increases. Yields of alfalfa were not significantly different. There was a small yield increase, however, with both the application of water and fertilizer up to 1000 lbs. of 0-15-30. Stands of all species were noticeably better at the medium and high fertilizer rates while irrigation water appeared to have little effect on the stand.

Title: THE EFFECTS OF SOURCE OF NITROGEN AND NUMBER OF APPLICATIONS ON DRY MATTER PRODUCTION AND NITROGEN RECOVERY OF MIDLAND BERMUDAGRASS

Leaders: A. Morris Decker and J. R. Miller

The study was initiated in the spring of 1960 to determine dry matter production and nitrogen recovery from ammonium nitrate and urea applied twice and four times during the growing season at rates of 200, 400 and 800 lbs. of N per acre. The experiment was laid out in a randomized complete block design at two locations in the Coastal Plain area of Maryland.

Dry matter yields from the first location ranged from 0.75 tons/acre with no nitrogen to 6.93 tons/acre with 800 lbs. N as NH_4NO_3 applied in 4 equal applications. Yields from the other location with a more fertile soil and near ideal rainfall ranged from 3.18 tons/acre with no nitrogen to 9.03 tons/acre with 400 lbs. N per acre (the highest rate used at this location) as NH_4NO_3 in 4 equal applications. Yields at both locations were higher for NH_4NO_3 than for urea. This was ture whether applied in 2 or 4 applications. Higher total yields and better forage distribution were obtained with 4 rather than 2 applications. This was particularly evident with NH_4NO_3 at the higher rates. The duration of the experiment will be a minimum of 2 years.

Title: THE EFFECTS OF NITROGEN RATES AND CLIPPING FREQUENCY ON THE PERFORMANCE OF MIDLAND BERMUDAGRASS

Leader: A. Morris Decker

Clipping and nitrogen treatments were continued as previously outlined (1959 Annual Report, page 56) with the exception that plots harvested 8 times in 1959 were cut only 7 times in 1960. One ton of lime was applied uniformly to the area during the late winter of 1959-60 and 2,000 lbs. of an 0-10-20 was applied in late spring.

Dry matter yields were substantially increased by the application of nitrogen up to 400 lbs. N per acre and tended to level off at the 600 lbs. rate. Yields ranged from 0.36 tons/acre with no nitrogen on plots cut 6 times to 5.85 tons/acre with 800 lbs. of N on plots cut 7 times. Total yields, however, were approximately 2 tons less for all treatments than were obtained the previous year. This appeared to be due to the combination of a low pH, excessive leaching and high plant removal. It was particularly evident at nitrogen rates above 200 lbs. per acre. As was found the previous year, yields were increased as the number of harvests was decreased from 7 to 3.

Title: THE EFFECTS OF CLIPPING HEIGHTS AND FREQUENCY OF HARVEST ON THE PERFORMANCE OF MIDLAND BERMUDAGRASS

Leader: A. Morris Decker

In the spring of 1960 a study was initiated to determine total dry matter production, seasonal distribution of growth, and forage quality as influenced by height of harvest and frequency of harvest at two nitrogen levels. The experiment was laid out on a 3 year old stand of Midland. The design of the experiment was a split plot with 4 replications utilizing nitrogen (200 and 600 lbs/acre) as the whole plot, frequency of harvest (3, 5 and 7 times per season) as the sub-plot and height of harvest (1, 2 and 4 inch stubble heights) as the sub-sub-plots. The starting pH was 6.5. The area was uniformly limed with 1 ton of lime and fertilized with 1 ton of 0-10-20.

Dry matter yields for the first harvest year ranged from 2.69 tons/acre for plots cut 7 times at 4 inches and nitrated with 200 lbs. N to 8.44 tons/acre for plots cut 3 times at 1 inch and nitrated with 600 lbs. of N/acre. Yields decreased as the height of stubble was increased. Extra nitrogen resulted in substantial yield increases. There were no significant interactions.

Title: SOD SEEDING ESTABLISHMENT TRIALS

Leaders: A. Morris Decker and F. Graham Swain

Experiments on sod seeding of species into Bermudagrass and Kentucky bluegrass have continued for the third year (1959 Annual Report, page 59).

The research with Midland has indicated that fall yields of sod-seeded rye can be significantly increased by closer row spacing (8 inches), higher seeding rates (180 lbs. per acre) and high nitrogen levels (90 lbs. N per acre). The responses to row spacing and nitrogen persisted throughout the season but the increase due to higher seeding rates was lost. Also, none of the previous sod seeding treatments adversely affected the subsequent summer production of Bermudagrass.

In another experiment rye and vetch were seeded alone and in combination on four fall planting dates. The rye-vetch combination, seeded on 3 dates, between early September and mid-October, produced significantly higher yields than either the rye or vetch alone. The late November planting of all treatment combinations was not satisfactory.

During 1960-61 the effect of different cutting intensities in combination with two row spacings and two seeding rates on fall production of sod seeded rye is being studied.

Considerable progress has been made in development of suitable openers for sod seeding small seeded legumes into Kentucky bluegrass. The development of a single row sod seeder has facilitated the testing of a wide range of opener types. A disc opener and a special wing attachment on the conventional opener have shown the most promise.

Title: CONTROL OF VARIOUS WINTER ANNUAL WEEDS IN ALFALFA AND ALFALFA-GRASS MIXTURES - 1960-61

Leaders: J. A. Meade and P. W. Santelmann

The Effect of CIPC on Seedling Grasses - Four forage grasses were seeded in September 1959 and treated on February 4, 1960 with 1 or 2 pounds of CIPC. Once again orchardgrass seems to be resistant to one pound per acre of CIPC. Brome, tall fescue and timothy were severely affected by the CIPC. When two-year-old orchardgrass was sprayed with 1 and 2 pounds of CIPC, there was no reduction in yield.

Control of German Knotgrass in Alfalfa - Plots were established in fall seeded alfalfa and treated at various dates with CIPC or DN. Four pounds per acre of DN applied twice through the winter will control this weed. A double application of 2 pounds per acre of CIPC also controls it as does a single application of 4 pounds per acre in January.

The Effect of Date of Treatment with 2,4-DB - Alfalfa seeded in September 1959 was treated during the winter with 1 and 3 pounds per acre of 2,4-DB. Although the alfalfa was dormant at the later date, both treatments severely reduced the yield of the first cutting.

Pre-emergence Control of Weeds in Alfalfa - Several herbicides were applied to newly seeded alfalfa on September 10, 1959. Of the materials tested only Dacthal gave good weed control. The 4 pound rate of this material significantly increased the yield of alfalfa. This experiment is being conducted again this year.

Title: FORAGE CROP INSECT INVESTIGATIONS

Leader: A. L. Steinhauer

Alfalfa - Problems are still mainly related to alfalfa weevil. Research on this insect with the aim of finding a satisfactory control is continuing. Results of 1960 insecticide tests did not yield information which would permit the design of a completely satisfactory control. The most effective treatment of alfalfa weevil was a combination of methoxychlor and malathion, which is the currently recommended practice. Other chemicals which gave indications of providing satisfactory control were EPN and Bayer 29493. Most other chemicals tried were generally unsatisfactory. Work on alfalfa weevil control is centered around a search for promising new chemicals, and new methods of using older insecticides effectively. Studies on the residues of chlorinated hydrocarbon insecticides are underway with the aim of determining the feasibility of utilizing these compounds safely from the standpoint of hay residues. Studies of varietal influence on weevil populations and coordination of spray timing with crop development and insect infestation are also underway.

The pea aphid is also a serious pest of alfalfa, which is always worse when chlorinated hydrocarbon insecticides are applied. Current studies are devoted to control of this pest as well as the meadow spittlebug in conjunction with alfalfa weevil control.

Clover - The lesser clover leaf weevil seems to be becoming more of a problem on red clover in Maryland. A limited study of this insect will be conducted this year. The clover root curculio is abundant in alfalfa, red clover and Ladino clover. A study of the economic importance of this insect during the past three years failed to show that its damage was involved directly in clover decline. It probably is involved indirectly in clover decline and may contribute to winter heaving, especially in alfalfa fields.

Many insects on forage crops in Maryland have never been studied as to their economic importance, since demands on time and the seriousness of the alfalfa weevil dictated the major emphasis for research. The recent establishment of a team of entomologists with the USDA at Beltsville for the sole purpose of forage crop research should help immensely to bring some of these insects to light, and contribute greatly to the solutions so badly needed in our forage crop work.

Title: THE EVALUATION OF PASTURES FOR LACTATING DAIRY COWS

LEADERS: N. A. Clark, A. M. Decker, Jr., Agronomy Department
R. W. Hemken, R. F. Davis, and J. D. Leslie, Dairy Department

Grazing of cereal rye sod seeded into Midland Bermudagrass pastures was initiated on April 1, 1960. Animal carrying capacity on the rye was quite high while the rye was in its greatest flush of growth. Milk production per cow was also very high while the cows were on the rye pasture. During the warmer part of the summer the management of the rapidly growing Midland Bermudagrass presented a problem in adjusting the animal stocking rate to the increased supply of forage.

Orchardgrass fertilized with three rates of nitrogen was compared with orchardgrass grown in association with Ladino clover as pasture for lactating dairy cows. Grazing of these pastures was started on April 19, 1960. Dry matter forage production and animal carrying capacity were comparable for the grass with the low rate of nitrogen fertilization (100 lbs. per acre) and the orchardgrass-clover association. Carrying capacity and dry matter production for the two higher rates of nitrogen fertilized grass were also comparable, and were significantly higher than for the other two treatments. This study will be continued in 1961.

Title: THE EVALUATION OF SUMMER ANNUAL PASTURES FOR LACTATING DAIRY COWS

Leaders: N. A. Clark - Agronomy Department
R. W. Hemken and J. W. Vandersall - Dairy Department

Grazing of summer annual pastures of Piper Sudangrass, Gahi No. 1 Pearl Millet, and a Sorghum-Sudangrass hybrid was initiated on July 1, 1960. Although the Sudangrass was most acceptable to the animals, and the Pearl Millet was less acceptable than either the Sudangrass or the hybrid, there was no significant difference in milk production on any of the three pastures. There appeared to be a slight depression in butterfat percentage in the cows grazing the Pearl Millet. This study will be continued in 1961.

Title: MANAGEMENT STUDY OF SUMMER ANNUALS

Leader: N. A. Clark

Sudangrass, Pearl Millet, and a commercial Sorghum-Sudangrass hybrid are being compared under 3 rates of nitrogen and 6 clipping treatments. Plants are cut at heights of 18 and 30 inches to stubble heights of 2, 4, and 8 inches. Results in 1960 show best recovery from the higher stubble, and greatest total yields from the 30-inch plants. Pearl Millet showed a greater response than the other two annuals to nitrogen. This study will be continued in 1961.

Title: GRASS AND LEGUME COMBINATIONS FOR BEEF PRODUCTION

Leader: A. Morris Decker

Two pasture mixtures, orchardgrass-Ladino clover and Reed canarygrass-Ladino clover, that had been under test during the past four years were compared with a pasture system composed of rye sod-seeded in Midland Bermudagrass sod, Kentucky bluegrass, Midland and rye in a prepared seed bed. Beef production from orchard and Reed canary was 387 and 390 lbs/acre respectively with most of it produced during the spring and fall. Grazing from the other pasture system was more evenly distributed and extended over a longer period of time. Beef production while on the Midland-rye was 811 lbs/acre, for bluegrass 324 and a loss of 164 lbs. on rye in a prepared seed bed in late fall. Even with this substantial loss, beef production was significantly higher than for the other two mixtures.

MASSACHUSETTS

Title: THE NITROGEN FERTILIZATION OF ORCHARDGRASS

Leaders: W. G. Colby, E. Bredakis and Mack Drake

At the outset this project was a potassium-nitrogen experiment on two series of plots, one seeded with an alfalfa-late orchardgrass mixture and the other with a Ladino clover-late orchardgrass mixture. (1957 Annual Report, pages 56-57, 1959 Annual Report, pages 62-63). At the beginning of the fifth harvest season in 1959, both legumes had disappeared from stands-- the Ladino clover from orchardgrass competition and the alfalfa from winter killing during the winter of 1958-59. A relatively pure stand of late maturing orchardgrass remained on both series of plots. The fertilizer program was changed to include a uniform application of potash on all plots and substantially higher nitrogen application rates than previously used. A time of cutting variable for the first harvest was also introduced. An excellent response to heavy rates of nitrogen fertilization was obtained for both the first and second cuttings. The response for the third cutting was very poor in many cases. Many plants showed severe injury and in some instances died. Our first explanation was that of fertilizer injury or burn since the plots most heavily fertilized exhibited the most extensive injury. When the plots were visited by Dr. M. R. Teel, he suggested that close clipping was responsible for much of the damage. Later, we observed that plots cut at successively later dates at the first harvest showed an increasing amount of midsummer injury. Therefore, in 1960 the experiment was modified to include (a) two different rates of nitrogen fertilization, (b) two different first cutting dates, and (c) two heights of cut.

Following are some of the factors involved with midsummer injury on orchardgrass:

(a) The effect of rate of nitrogen application - Late in April urea nitrogen was applied to all plots at a rate of approximately 135 lbs. of nitrogen per acre. Following each cutting urea nitrogen was applied at two rates: 50 lbs. of N on one series of plots and 100 lbs. of N on the second. There was no question but that the plots receiving 100 lbs. of N after both the first and second cuttings, showed much more injury in August than those less heavily fertilized. A few plots to which potash had been applied in addition to urea had no more injury than urea alone.

(b) The effect of growth stage at first cutting - In 1959 three cutting dates were included (1) early heading, (2) fully headed, and (3) early bloom. In 1960 only the first two were included. The results for 1960 were essentially the same as those from 1959 -- "late" first cutting plots had much more midsummer injury than "early" first cutting plots.

(c) The effect of height of cut - Two heights of cut approximately 1 1/2 in. and 3 in. were employed. In all cases close clipping resulting in greater injury than high clipping. All three factors - time of first cutting, height of cut, and rate of nitrogen were additive. The most severe injury occurred on plots with the highest rate of nitrogen fertilization, the latest first harvest and the close clipping. Of the three factors involved, the stage of growth at first cutting appeared to be most important.

A fourth factor, midsummer temperature, may be involved. To test the effect of close clipping and heavy fertilization on this "midsummer" injury, a greenhouse pot experiment was conducted by a student, Gregory Terkanian, during the winter of 1959-60. Potted orchardgrass plants were given two clipping treatments, 3" and ground level, and varying rates of nitrogen and potash fertilization. Five harvests were made and although yields were slightly greater on the higher clipping treatment and also the high nitrogen, in no case were injury symptoms characteristic of "midsummer" injury induced. We believe there is no complete and fully satisfactory explanation yet available for the injury that occurs with orchardgrass in midsummer following heavy nitrogen fertilization.

Title: INVESTIGATIONS OF FORAGE CROP INSECTS IN MASSACHUSETTS IN 1960

Leaders: F. R. Shaw and W. J. Fischang

Investigations conducted in 1960 included census studies of major pests throughout the state and the testing of several insecticides to control pests of various forage crops.

The distribution and numbers of forage crop insects were determined through periodic collections from all major agricultural counties, excluding Cape Cod and the off-shore islands. Fields in the Amherst area were sampled at weekly intervals throughout the season in order to determine population differences with changes in season and composition of stand. A total of nearly 147,000 insects was collected and identified from April through December. Collections consisted of 100-sweep samples made with a 15 inch sweeping net. Table 4 indicates relative abundance of the major insect species found.

Pea aphids (Macrosiphum pisi) were much more numerous in 1960 than they had been for the two previous years. Perhaps greater than usual summer precipitation may have provided aphids with optimum conditions for a longer period. While large numbers of pea aphids had been collected only in spring or fall in previous years, 1960 found large populations during mid-summer.

Hypera postica, the alfalfa weevil, was widespread throughout Massachusetts in 1960, yet populations were generally very low. Highest populations occurred in southern Berkshire and Hampden Counties in late May and early June. While not severe, gross damage to alfalfa stands was observed in the southwest corner of the state, with populations of 26 and 38 larvae per 100 sweeps. Larvae collected in Amherst on 14 November pupated within 4 days after being held caged on potted alfalfa in the laboratory. As late as 5 December, larvae could be collected in Amherst by sweeping.

Empoasca fabae, the potato leafhopper, was first collected on 28 May in Hadley. Populations of E. fabae throughout the state were generally quite low, seldom reaching as many as 50 per 100 sweeps. The largest population collected totaled only 133 leafhoppers, on 15 September. E. fabae could still be collected as late as 5 December in Amherst. In terms of percentage of total insects collected, the leafhopper populations, as a group, were somewhat below the 1959 figures.

Meadow spittle bugs (Philaenus leucophthalmus) were numerous on alfalfa in some areas. Heaviest infestations occurred in Berkshire County in early June, with averages as high as 2 spittle masses per stem. Rosetting of alfalfa was common in fields where high populations were found.

Five fields were sampled weekly during the season to learn of differences in insect populations with different stand compositions and to determine major seasonal population fluctuations. While no conclusive differences in insect populations with varying stands appeared, aphids seemed somewhat less successful on a mixture of red and Ladino clover than on alfalfa or mixtures of alfalfa and red clover. Pea aphid populations reached an apex during the last week of May and again from mid August until early September. Halticus bracteatus, the garden flea hopper, demonstrated the remarkable feat of increasing from 12 individuals per 100 sweeps to an estimated 2,200 in a 1 week period. This increase occurred on an excellent stand of alfalfa and red clover. Tarnished plant bugs (Lygus lineolaris) were most numerous in all stands during the latter part of September, with populations as high as 460 per 100 sweeps.

Table 4. Census of Forage Crop Insects in Massachusetts 1960

Insect name or group	% of group	% of total
Aphids (mainly Macrosiphum pisi)		68.9
Plant bugs		12.9
Lygus lineolaris	48.6	
Halticus bracteatus	25.3	
Leptoterna dolabratus	9.8	
Adelphocoris lineolatus	5.1	
Trigonotylus ruficornis	3.5	
miscellaneous Miridae	2.2	
Adelphocoris rapidus	1.9	
Plagiognathus politus	1.8	
Megaloceroea recticornis	1.2	
Capsus spp.	.5	
Leafhoppers		7.5
Empoasca fabae	20.9	
Macrosteles fascifrons	20.3	
Endria inimica	17.2	
Graminella nigrifrons	12.0	
Aceratogallia sanguinolenta	9.1	
miscellaneous leafhoppers	6.8	
Draculacephala spp.	4.7	
Paraphlepsium irroratus	4.0	
Helochara communis	1.7	
Scaphytopius acutus	1.6	
Scaphytopius frontalis	1.1	
Predators		2.6
Nabis ferus	32.9	
Coccinellidae	28.4	
Chrysopidae	14.3	
Syrphidae	9.1	
Orius insidiosus	6.4	
miscellaneous predators	1.1	
Reduviidae	.6	

Insect name or group	% of group	% of total
Beetles		1.9
Hypera postica	23.7	
Sitona hispidula	16.3	
miscellaneous beetles	15.5	
Popillia japonica	12.9	
Tychius stephensi	9.6	
flea beetles	9.5	
Elateridae	3.9	
Hypera punctata	1.8	
Rhinoncus castor	1.4	
Sitona flavescens	.9	
Hypera nigrirostris	.9	
Calomycterus setarius	.9	
Sitona scissifrons	.5	
Miscellaneous insects		1.8
Collembola		1.4
Spiders		1.2
Philaenus leucophthalmus		.8
Fulgoridae		.3
Lepidoptera		.3
Grasshoppers		.3
Sawflies		.2
Thrips		.1
Membracidae		.1

Tests of Insecticides to Control Forage Crop Pests

In order to determine the comparative effectiveness of some of the newer insecticides, plots containing strips of red clover, Ladino clover, alfalfa and birdsfoot trefoil were sprayed with the following insecticides: Thiodan at 0.75 lb. actual per acre, Guthion at 0.75 lb., Dylox at 1.5 lbs., malathion (SF-60) at 0.5 lb., dimethoate at 0.5 lb., and Thuricide at 2 lbs.

Thiodan, Guthion, malathion, dimethoate, and Dylox showed promise against many of the forage crop pests up to 10 days after application. Against pea aphids excellent control resulted from applications of all of the materials listed above except for Dylox and Thuricide. Most of the plant bugs were similarly controlled except for *Lygus lineolaris*. Dylox gave satisfactory control of this pest up to 10 days after application but the plots receiving malathion, dimethoate, Guthion or Thiodan had population increases at 7 days. Thuricide was ineffective against this pest. Against leafhoppers, all of the materials except Thuricide were effective in some cases up to 10 days after application. Dimethoate and Guthion gave the best results. Dylox and dimethoate appeared to give the greatest reduction of the predaceous *Nabis ferus*.

In a second experiment, Guthion at 0.5 lb. actual per acre resulted in excellent control of the garden fleahopper (Halticus bracteatus) on Ladino and red clover for at least 6 days. Among the leafhoppers, only Empoasca fabae and Macrosteles fascifrons were present in sufficient numbers to yield conclusive results, and both were well controlled up to 6 days after treatment. In general, numbers of plant bugs were reduced, but control was considered unsatisfactory. Populations of Nabis ferus were appreciably reduced. While pea aphids were not present in large numbers on Ladino clover, they were satisfactorily controlled for 6 days on red clover.

Malathion (SF-60) at 0.75 lb. actual and dimethoate at 0.25 and 0.75 lb. actual were compared in a third experiment for insect control performance on plots of Ladino clover and alfalfa. Generally all 3 dosages gave good control of several insects up to 12 days following treatment, with dimethoate at 0.75 lb. giving best control. Pea aphids were well controlled by all 3 dosages 12 days after treatment. Good control of most leafhoppers was maintained by 0.75 lb. dimethoate for 12 days while malathion and 0.25 dimethoate showed sporadic results after 5 days. Fair control of tarnished plant bugs by the 3 dosages was evident through 12 days. All 3 gave outstanding results up to 12 days against Halticus bracteatus, the garden fleahopper.

In a final experiment, Sevin 85% WP was applied to plots of birdsfoot trefoil, red clover and Ladino at 1.5 lbs. actual per acre. The treatment was satisfactory against leafhoppers but gave inconclusive results against pea aphids and plant bugs when sampled at one and three days after spraying.

NEW HAMPSHIRE

Title: IMPROVEMENT OF SMOOTH BROMEGRASS, RED CLOVER AND ALFALFA

Leaders: G. M. Dunn, L. J. Higgins and James A. Wright

Progeny and strain testing were continued in bromegrass for resistance to brown leaf spot and improved summer production. Syn 1 seed was obtained from all possible single crosses among 6 selected bromegrass clones. An attempt will be made to advance these to the Syn 2 generation for a comparison of Syn 1 and Syn 2 performance.

Genetic studies were begun with yellow plants and 2 rolled leaf mutants obtained by inbreeding. Several yellow x green crosses were made. In most cases, F_1's appeared green, but a few F_1 plants appeared intermediate in color. Many yellow plants were quite vigorous, but some were very weak.

Various intensities of color, ranging from green to almost white, were produced by selfing of yellow plants. Apparently, no homozygous yellow plants have yet been identified. Some of the parents and F_1's are being analyzed chemically for protein, chlorophyll a & b, and the carotenoids. F_2 populations are now being produced in the greenhouse.

Two rolled leaf mutants were obtained from one inbred line. About 15-20 F_1's of rolled leaf x normal appear to be normal.

We plan to expand genetic studies in this species.

More seed of New Hampshire red clover from potted plants in the greenhouse was again obtained with the assistance of bees. The ten red clover varieties planted in four replications, August 6, 1959 in chemically treated soil came through the winter as nearly perfect stands. Harvests, in the early bloom stage, gave the following average yields for all plots: June 14, 3.36 tons per acre, July 18, 1.92 tons and August 24, 1.15 tons. Before the complete analysis is made, high yielding varieties appear in alphabetical order, Dollard, Lakeland, LaSalle, New Hampshire and Pennscott.

Title: EVALUATION OF FORAGE SPECIES

Leaders: R. F. Lucey and N. F. Colovos

Species tests established in Nashua and Groveton, New Hampshire during the fall of 1958 were evaluated in 1959 and 1960. Saratoga bromegrass and Climax timothy were the most productive. S-37 orchardgrass was least productive, while the yields from Reed canarygrass were intermediate. S-37 suffered winter injury in 1958 and 1959. It appears that this variety of orchardgrass is not sufficiently winter hardy to persist and to produce high yields in New Hampshire. Also, S-37 is very susceptible to Scolecotrichum graminis.

Growth measurements and herbage samples are being taken for each grass species on several dates. The samples are being analyzed for acid insoluble lignin, gross energy and protein. The lignin and protein contents of Climax timothy harvested in 1959 are summarized as follows:

Table 5. Content of certain chemical constituents of Climax timothy sampled on several dates, 1959.

Location	Sampling date			
	May 15	June 1	June 15	July 1
	% acid insoluble lignin			
Groveton	2.19	3.82	5.15	6.70
Nashua	2.36	3.30	6.20	7.91
	Protein			
Groveton	29.12	14.01	12.87	9.55
Nashua	24.60	12.34	8.36	5.82

Yields were obtained for the second harvest year for the legume-grass mixtures which were seeded in the fall of 1958 in Groveton. The red clover-grass mixtures, which were the most productive in 1959, were the least productive in 1960.

Significantly higher yields were produced in 1960 by the alfalfa-grass mixtures. The Ladino clover-grass mixtures were more productive than either the birdsfoot trefoil or the red clover-grass mixtures.

Title: COMPARATIVE LIFE HISTORY AND DISPERSAL OF SITONA FLAVESCENS AND S. HISPIDULA

Leader: William R. Lee

Larval populations of Sitona spp. in white clover fields of New Hampshire reach peak in early June and a second peak in September. Life history studies show the June larval population to be predominately S. hispidula (F.) and the September larval population to be predominately S. flavescens Marsh.

During the summers of 1957 and 1958 S. hispidula was far more prevalent than S. flavescens; during 1959, however, S. flavescens outnumbered S. hispidula, as the previous severe winter with little snow cover had greatly reduced the S. hispidula population. In 1960 the populations of the two species were approximately equal.

Although efforts to use traps in studying migration habits of these species were unsuccessful, information on migration habits was obtained by observing the larval infestation in clover plots planted at different times. During June and July a four year old stand of white clover had an average of 34 larvae per square foot; yet plots planted in early May, 1960, whose borders were not more than 50 feet from the four year old plot had no larvae. Plots in another field planted in August, 1959, averaged 10 larvae per square foot. During August and September all plots were infested with S. flavescens larvae. Therefore, although overwintered adults of S. hispidula are laying eggs during late May, they do not migrate to new fields at that time.

Title: FORAGE SYSTEMS

Leaders: R. A. Andrews, R. F. Lucey, G. L. Byers, G. W. Angell and H. A. Keener

A project with the objectives listed below has been activated as a joint responsibility of Agricultural Economics, Agronomy, Agricultural Engineering, Dairy Science and University Farm. It is intended to serve as a means of integrating more basic research before it is taken to the farmer.

Objectives:— (1) To study the growing, harvesting, processing, and feeding of forage in terms of selected complete systems currently in use. This will be done on a large volume rather than a small plot base. Studies of systems will begin with soil management and continue through to the production of milk. (2) To develop and test new forage systems. This might include new structures, machines, and management levels. (3) To study alternative forage systems from the standpoint of observing how they influence net farm income.

Title: IMPROVEMENT OF WHITE CLOVER

Leaders: G. M. Dunn and R. A. Kilpatrick (in cooperation with Forage and Range Research Branch, A.R.S., U.S.D.A.).

Progeny testing for persistence was continued with selected Ladino clover clones. Five Ladino clones were intercrossed in all possible single cross combinations under cages. These will be advanced to the syn 2 generation for comparison with the syn 1. Ten synthetics, involving 2 to 5 parental clones each, were transplanted to the field for seed production in 1961.

Studies were continued on 1958 dieldrin and methyl bromide plots (1958 Annual Report, page 88) and on a similar planting made at 2 locations in 1959. Dieldrin has effectively controlled Sitona spp. for 2 years, but neither treatment significantly reduced root rot in the field. An excellent stand was obtained in the 1959 seeding. Methyl bromide and methyl bromide plus dieldrin produced higher yields than control plots at both locations. The increase seems to be largely due to weed control with methyl bromide, since dieldrin alone did not significantly increase yield. Populations of Sitona larvae increase in the spring and fall in New Hampshire. The spring population appears to be predominantly S. hispidula, the fall population largely S. flavescens.

Results to date indicate that most taproots of white clover are dead within about 24 months after seeding. Although dieldrin effectively controlled Sitona spp. neither dieldrin nor methyl bromide significantly reduced root rot in the field, and it appears questionable whether dieldrin will significantly influence yield or persistence.

Highly significant increases were obtained in dry weight of tops, stolons and roots from 400 to 800 f.c. Only slight increases were obtained from 800 to 1200 f.c. Temperatures used were 65°F. (night) to 75°F. (day), at a day length of 16 hours. Evidence was obtained for a genotypic response to light intensity.

A study was conducted on rooting of stem cuttings of red clover. Tip cuttings rooted better than basal stem cuttings, and cuttings from non-flowering plants rooted better than from flowering plants. Only slight increases were obtained from use of a rooting hormone.

Taproots of Ladino white clover were examined for the internal breakdown condition (I.B.) found near the crown. The condition was most commonly found in plants in the fall of the first harvest year. Isolations from I.B. tissue yielded many fungi. However, slightly discolored sections yielded no fungus or bacterial isolates. The condition appears to be associated with age and fungi seem to act as secondary invaders.

One-hundred and forty-four maintenance clones were indexed for viruses. Fifty-four percent of the clones contained both alfalfa mosaic and bean yellows; 31% were infected with bean yellows alone; and 15% were infected with only alfalfa mosaic. None of the clones tested was free of virus infection.

Studies were continued on factors affecting cold hardiness of clovers. Preliminary data indicate that rapid thawing following freezing is more beneficial for survival than slow thawing. Temperatures of dry soil, during the freezing process, are more constant than those in wet soil. Seedlings in the cotyledonary, unifoliolate, and first leaf stage appear more susceptible to freezing than plants in the 3-6 leaf stage of development.

The root knot nematode was found for the first time in plots at Northwood. Small galls were found on secondary roots. Galls have never been observed on roots from the plots at Dover.

Sampling of Ladino taproots and soil for stylet-possessing nematodes from dieldrin and methyl bromide plots was made from 2 dates of planting at 2 locations. Methyl bromide controlled the stylet nematodes while dieldrin treated plots yielded more than control plots. Apparently dieldrin killed some of the predators attacking the nematodes.

Cultural studies with Stagonospora meliloti indicated numerous morphological types of isolates. Variation exists between isolates in color and amount of mycelium, presence or absence of pycnidia, and rate of growth on different types of media.

Preliminary studies showed that crown injury of alfalfa and red clover was more severe on plants with greater tractor slippage. Injury to plants was less when slippage was made with new tires than with old tires.

Title: WATER AND FERTILIZER REQUIREMENTS OF SELECTED CROPS AND SOILS AS RELATED TO IRRIGATION

Leaders: A. B. Prince and P. T. Blood

Three lysimeter experiments were conducted in a growth chamber. The effects of water treatment and soil temperature on the yields of test crops, amount of water moving through the soil and amount of cations leached were studied. Preliminary data indicate the following:

(1) The highest yield of oats (forage) was obtained at a soil temperature of 25°C. Other soil temperatures were 18°C. and 30°C.

(2) Low soil temperature and heavy irrigation always caused a great leaching loss of water. However, plant growth as related to evapotranspiration modified this general relationship.

(3) In general, leaching losses of cations from the soil were positively related to the amount of leachate. Therefore, a large amount of water applied at low soil temperature and the resulting reduction in plant growth caused an increase in loss of cations. The order of magnitude of cations appearing in the leachates was Ca > Mg > K.

(4) Application of Ca, K, and Mg in fertilizers increased the cation content of the soil by a factor of 3, 1.6 and 2, respectively. However, the degree of increase at different depths depended on each individual cation. As compared with the original content of the soil the greatest increase of both Ca and Mg was in the 9-15" layer, while the greatest increase for K was in the 0-9" layer. (Merrimac soil)

(5) The significance of soil temperature on uptake of Ca, Mg, and K by oats was greater than frequency or amount of irrigation, providing that moisture was not seriously limiting plant growth.

(6) The highest dry-weight yield of perennial ryegrass was obtained at a soil temperature of 25°C. and with applications of water at the rate of 2-acre-inches per week.

(7) There was no apparent effect of water treatment or soil temperature on the total Ca content of the plant material.

(8) The percent of Ca in the plant derived from the added $CaCO_3$ was less when the plants were grown at a soil temperature of 25°C than at 18°C.

(9) Water loss from the lysimeters was greatest at a soil temperature of 18°C. when cropped or at 25°C. when fallowed.

(10) Also water loss was greatest when 3 acre-inches per week were applied and least when 1 acre-inch per week was applied.

(11) The amount of extractable soil Ca which was derived from the added $CaCO_3$ was extremely small (0.0001 - 0.25me/100gn soil). N neutral ammonium acetate was used as the extractant. (Agawam soil)

NEW JERSEY

Title: GENETICS AND BREEDING OF FORAGE LEGUMES

Leaders: W. R. Battle and F. J. Olsen

The study of inheritance of characters associated with feeding value in alfalfa has been completed and is being summarized. Significant variations existed among families with respect to yield, plant height, stem number, time to maturity, leaf percentage, protein percentage, and total yield of protein. Yield was positively associated with leaf percentage but negatively with protein percentage. Plant height and leaf percentage were negatively associated. The correlation of protein percentage and leaf percentage was positive and approached significance. Protein percentage, time to maturity, stem number, and plant height were highly heritable.

Title: TILLERING STUDIES OF ALFALFA

Leaders: M. A. Sprague and Everett R. Cowett

For three years a study has been underway to determine the nature of crown bud activation and subsequent shoot development in alfalfa, and to observe the extent to which the usual tillering sequence is altered by the environment. Factors studied included soil moisture, light intensity reaching the tops, light intensity reaching the crowns, mineral nutrition, plant growth regulators, photoperiod, cutting treatments, and stand densities. This was essentially a survey of a wide variety of treatments which might affect bud initiation.

Tillering was gradual and continuous on alfalfa seedlings but rather abrupt after cutting and discontinuous after 2 or 3 weeks on established plants. Soil moisture, light intensity, temperature, and mineral nutrition appeared to affect tillering only as they affected the vigor and growth of the plants. The tillering sequence of established plants was enhanced by short photoperiods and antiauxin applications. Cutting alfalfa high from the crown increased the number of stems but did not affect the lower crown portions. Plants cut late produced more stems than those cut earlier but no differences were noted between early bud and early bloom stages. As stand density decreased, the number of stems per plant increased. Similarly, stand densities altered soil and air temperatures, soil moisture, light intensities reaching the crown, and several other climatic factors. In general, those management factors which are thought to alter food reserves in roots and crowns affected most the numbers of tillers per plant. Carbohydrate nutrition may be important in determining crown development.

Title: PASTURE RENOVATION

Leaders: M. A. Sprague, R. D. Ilnicki, and R. W. Chase

Experiments were extended to determine factors influencing the effectiveness of dalapon, cacodylic acid, and amitrol for use in pasture renovation. Factors included season of use, combinations and rates of chemicals, selectivity of chemicals and tolerance of species, and competitive seedlings vigor.

The effectiveness of chemicals when used in late fall was poor; during early and middle fall was good. Completeness of kill of old sod markedly influenced the growth and establishment of species, both perennial and annual. Considerable tolerance to cacodylic acid of orchardgrass and alfalfa was observed in the greenhouse. Less was observed by bromegrass and least by Kentucky bluegrass. This suggests opportunity for selectively eliminating stands of some crops preparatory to seeding desirable species. Dalapon in combination with

amitrol or cacodylic acid continued to be effective during warm seasons at economic rates below $10 per acre. In preliminary tests arsonic acid at 12 pounds per acre showed some promise as an herbicide.

Title: HARVEST MANAGEMENT OF FORAGE MIXTURES

Leaders: M. A. SPRAGUE AND EVERETT R. COWETT

An experiment has been underway since the fall of 1956 to determine the effects of cutting managements and fertility on yield and stand persistence of forage mixtures. Four mixtures included alfalfa-bromegrass, alfalfa-orchardgrass, Ladino clover-bromegrass, and Ladino clover-orchardgrass. These were subjected to 12 cutting treatment combinations including pasture, silage, and hay cuttings in spring and in combination with pasture and hay cuttings in the summer and again in fall. Two levels of 0-15-30 were employed. Cutting managements continued for three seasons. In 1960 all plots were harvested uniformly at mature stages and yields, percentage grass, legume and weed compositions determined by hand separations.

Higher total yields were obtained from mixtures containing orchardgrass than bromegrass and total yields were reduced where either all cuttings were in the pasture stage or the last cutting of the season was in the pasture stage of maturity. The percentage of seeded species remaining in the stand was differentially affected by cutting treatments. Ladino clover persisted far better with bromegrass than with orchardgrass and orchardgrass grew better with Ladino clover than with alfalfa. All plots of either legume, but especially alfalfa receiving the final one or two harvests each season in the pasture stage showed significantly reduced stands. The stage of maturity at the first harvest had no such effects. Although fertility levels revealed only slight effects on the persistence of grass and legume, high fertility favored alfalfa in the mixture while low fertility favored Ladino clover.

Title: CORRELATION OF SOIL TEST LEVELS FOR P, K AND MG WITH PLANT GROWTH RESPONSES

Leaders: W. J. Hanna and R. L. Flannery

Atlantic alfalfa, in the third year on Dutchess soil, with yields of about 3 tons an acre, showed no response to the addition of phosphorus and potash, when the soil test level for P was above 5 lbs. and for K was above 115 pounds per acre.

Title: INFLUENCE OF PERCENT CALCIUM SATURATION OF THE EXCHANGE COMPLEX AND FERTILIZATION OF DUTCHESS SOIL ON ALFALFA PRODUCTION

(In cooperation with Dairy Science Department)

Leaders: R. B. Alderfer and C. H. Ramage

Analyses of the soil from the differently limed and fertilized plots show the following:— (1) The effect of different amounts of calcitic limestone applied in 1956, to achieve 65%, 100% and the equivalent of 150% calcium saturation can still be detected by pH and exchangeable Ca measurements. The unlimed soil has a pH of about 5.5 and a calcium saturation of 35%. Use of 4 1/2 to 6 tons of limestone to achieve 150% Ca saturation has held the pH above 6.5 and left about 85% Ca saturation. More modest rates of lime application have left pH's between 6.0 and 6.5 with residual Ca saturations between 50 and 60 percent.

Yield and stand of Atlantic alfalfa in its 4th year increase with pH and Ca saturation. Maximum yields are about 9,000 lbs. an acre. (2) Uptake of potassium by alfalfa, fixation by the soil and leaching losses account for a decrease of nearly 200 pounds of exchangeable soil K between April and October. The decrease is greatest in the most heavily fertilized plots (240 lbs. K_2O an acre).

(3) The amount of exchangeable K left in Dutchess soil under alfalfa at the end of the growing season even with heavy annual rates of potash fertilization, is about 75 pounds an acre. This would not be enough to satisfy the K requirements of alfalfa for the next growing season.

Title: HIGH NITROGEN GRASS PRODUCED BY HEAVY NITROGEN FERTILIZATION

Leader: C. H. Ramage

Eight year old orchardgrass and Reed canarygrass plots, established in the fall of 1952, produced more forage dry matter per acre than in any previous year. Weeds (largely dandelion) are a problem only on the check plots receiving no nitrogen. There has been some loss of stand on the orchardgrass plots receiving very high rates of nitrogen. Some plots have been invaded by quackgrass. Supplemental phosphorus and potash have been applied. Yields in 1960 were as follows:

ORCHARDGRASS

	0#N	50#N	100#N	150#N	200#N	300#N	400#N	600#N
D.M., lbs/acre	5000	6350	7650	9050	9750	10,300	10,500	10,250
Protein, %	12.16	13.06	12.71	13.05	16.54	17.51	18.09	20.21
Protein, lbs/acre	608	830	971	1182	1616	1804	1997	2076
% N recovery	----	71.0	58.1	61.2	80.6	63.8	55.6	39.1

REED CANARYGRASS

D.M., lbs/acre	3900	5550	7100	8250	9150	9650	10,100	9800
Protein, %	14.16	15.27	14.31	14.42	17.88	20.63	22.44	23.48
Protein, lbs/acre	550	844	1014	1191	1634	1986	2264	2305
% N recovery	----	94.1	74.2	68.4	86.7	76.6	68.6	46.8

Title: ORCHARDGRASS PASTURE RESPONSE TO NITROGEN FERTILIZER

Leader: C. H. Ramage

Pasture trials during 1960 consisted of fertilizing two orchardgrass pastures with nitrogen, supplemented with phosphorus and potash. The growth response to the nitrogen was excellent as rainfall was plentiful and well-distributed. Waste of the forage grown seemed unavoidable, and amounted to about 25% of the total growth. Results are shown as follows:

Pasturings	Fertilizer applied, lbs/acre N	P_2O_5	K_2O	Total Growth	Ungrazed	Utilized	% Utilization
5	200	80	80	9,503	2733	6700	71.2
5	300	120	120	11,305	2749	8556	75.7

Title: FERTILIZER STUDIES WITH ALFALFA

Leader: G. H. Ahlgren

Yield data in the ninth harvest year show no response to nitrogen applied at rates of 25, 50, 100 and 200 pounds of N each spring. Similarly, phosphate applied at 50, 100, 200 and 400 pounds of P_2O_5 per acre has shown no response, yields ranging from 4.22 tons per acre to 4.63.

With potash the following results were obtained: None, 1.73 tons per acre; 50 lbs., 1.98; 100 lbs., 3.70; 200 lbs., 4.63; 300 lbs., 5.00; and 400 lbs., 5.46. This is the hay element in alfalfa production.

In recent years yields are being favored by the 0-1-3 and 0-1-4 ratios over the 0-1-1 or 0-1-2. Also at least 200 pounds or more of potash must be applied annually as a minimum requirement to help maintain stands and secure high yields.

Highest returns have consistently attended the application of all fertilizer on alfalfa as a single spring treatment. The following data were obtained this year:

Treatment	Tons/Acre
None	1.37
Spring	5.02
Fall	3.04
Last Cutting	4.22
S-F	4.44
S-L	4.70
F-L	4.07
S-F-L	4.65

Title: SILAGE INVESTIGATIONS

Leaders: M. A. Sprague, Luigi Leparulo

Investigations of factors affecting the efficiency of preservation of forages as silage continue with studies on corn and sorghum species. Analyses were completed of silages preserved in 1959 comparing orchardgrass, bromegrass, barley, and oats in pure stand at the bloom stage of maturity and alfalfa at early and late bloom stages of maturity.

Total dry matter losses were consistently very low and surface losses in the vinyl envelopes were in all but one case negligible. Seepage losses existed only where moisture contents at harvest exceeded 80 percent. Fermentation losses were consistent with earlier findings and ranged from 3.7 to 10 percent. Protein content of the green forage and total dry matter losses were inversely related. This relationship was not so strong with sorghum as with other species. Crops of later maturity were preserved more efficiently than those of early maturity. Moisture content of the younger forage was similarly associated.

Protein losses were related to protein content of the forage and to maturity. However, sorghum differed from corn in this respect, when both were harvested at the same stage of maturity; this late maturing forage, low in protein, showed high percentage losses. Perhaps this crop has a different protein. Only one silage had a pH above 4.0. Volatile bases generally reflect ammoniacal nitrogen, considered to be a product of protein breakdown. Accordingly, a comparison of these values with amino acid content offers a more complete picture of protein relationships. Digestibility determinations of some of these silages with sheep showed barley to be superior in digestibility of all constituents to silages made from orchardgrass, bromegrass, or oats harvested at the same maturity and superior to alfalfa in all items except protein. Corn exceeded digestibility of barley in energy, ether extract and nitrogen-free extract. Barley, although young in maturity and having some losses as seepage in these silage trials, showed fermentation losses of only 5 to 6 percent.

Title: INVESTIGATIONS CONCERNING THE YIELD, NUTRITIVE VALUE, ADAPTABILITY, AND MANAGEMENT OF SOME GRASSES AND LEGUMES, ALONE AND IN ASSOCIATION, FOR HORSE PASTURES

Leader: R. W. Duell

Increasing the rates of application of 10-10-10 to 2000#/A in each of three applications increased the yields of Midland Bermudagrass to more than 8.5 tons of oven dry matter per acre. The protein and mineral contents of this

forage were also high. Fertilizer rates will be increased further and minor elements will be added in an attempt to attain maximum production.

The first tests of herbicides in the establishment of Midland Bermudagrass indicated success and point to ultimate complete mechanization of this planting operation, which ordinarily requires much hand labor. Control measures for Bermudagrass are also being studied.

We find it impossible to maintain the initial yield advantage of high seeding rates of sudangrass, even with high rates of complete fertilizers. The rates of seeding presently recommended should continue. The importance of early utilization of sudangrass for pasturage, along with a high stubble should be stressed to farmers. Wheeler sudangrass continues to be superior as a warm-season annual pasture species, but no management technique was found to assure adequate regrowth from the pearl millets.

In the 5th harvest year of grass fertilization plots managed to simulate rotational grazing, bromegrass, and to a lesser extent, timothy and Reed canarygrass have become sparse, while Kentucky bluegrass, orchardgrass, and tall fescue remain dense and productive. The latter grasses respond well to applications of nitrogenous fertilizers both in the spring and early summer, particularly with favorable moisture conditions such as in 1960. After two years of fertilization with NH_4NO_3, yields are almost as good as those from 10-10-10. With NH_4NO_3 fertilization the plant potassium content is very low, but apparently the soil supply capacity suffices.

NEW YORK (CORNELL)

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS

Leaders: R. P. Murphy, R. E. Anderson and C. C. Lowe

The backcross breeding program, to add resistance to bacterial wilt to Narragansett and to Flemish-type alfalfa, is being continued. (1959 Annual Report, page 83). Selected plants, primarily from the third backcross generation, have been intercrossed during the winter of 1960-61.

The study of the variation in seed production within Narragansett is being continued. A study of chromosome number and pollen stainability has been completed for the plants selected in Wyoming in 1957 and in California in 1958. Fifty high-seed-set plants were selected each year. Twenty-seven low-seed-set plants were selected in 1957 and 25 in 1958. All these clones had 32 chromosomes except the following: (1) low-seed-set clone with ± 48; (2) low-seed-set clone with 33; and (3) high-seed-set clone with 33. The high-seed-set clones were usually higher in percent stainable pollen than the low

group. However, some low-seed-set clones had high or very high percent stainable pollen. It was concluded that percent stainable pollen has little predictive value for selecting plants with high-seed-set. There did not seem to be a strong positive relationship between high percent stainable pollen and low meiotic irregularities. However, plants with high meiotic irregularities and/or very low pollen stainability were never high in seed production as females, although they were usually effective as males on clones with high seed-set.

A synthetic (25 clones) of high-seed-set clones has been produced and is being evaluated for forage performance in comparison to "standard" Narragansett and other varieties.

The genetics of the creeping-rooted character is being studied in a series of intercrosses and backcrosses involving differing phenotypic types of creepers and non-creeping clones. The field planting established in 1960 as spaced plants consists of vegetative cuttings of the creeping and non-creeping parents, F_1 progenies, and backcrosses to both parents. Additional data on linkage of other characteristics with the creeping habit will be tabulated from this nursery. First-year data on a comparable nursery established in 1959 indicate that sod competition reduces the percent of phenotypic expression at that stage of plant development. Three seed lots of creeping rooted material are available in sufficient quantity to plant limited plots of broadcast seedings in 1961.

Studies on singlecross and selfed progenies of timothy (crosses were made under cage without pollination control) have given some very interesting information on the inheritance pattern for maturity and height. Progeny averages for these characters were very close to the midparent values in most crosses. General combining ability values for selected clones were highly related to clonal expression for these characters. Averages of selfed progenies were only slightly less than the clonal values; where deviations of crosses from midparent values occurred, they could often be traced to selfed seed from the maternal parent. While the data indicated that the heritability of both height and maturity expression was very high and that clonal selection alone would be sufficient for these traits, the opportunity for selfing or nonrandom pollination of clones in crossing blocks could be considerable and possibly undesirable. Clones going into synthetic combinations should be matched closely in maturity to assure maximum crossing and less opportunity for genetic shift in the increase generations. Differences in seasons were observed to have considerable effect on the synchronization of flowering of specific clones. A procedure of several periodic ratings for maturity covering the period from boot to bloom has been found superior to relying solely on first anthesis in specific seasons as a reliable indicator in clone selection for maturity.

Title: BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO NEW YORK AND ADJACENT AREAS OF THE NORTHEAST

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy and A. A. Johnson

Tests on 96 polycross progenies of second cycle of selection bromegrass clones were concluded. (1959 Annual Report, page 84). The best of these clones (on basis of progeny performance) have again been polycrossed and will be progeny tested for regional adaptation through cooperation with other Northeastern States. The current trials were conducted under two management systems: three, and four cuttings per season. One system involving removal of first growth 2 1/2 weeks before the normal first anthesis date (first cut about May 25th), followed by harvests at 5 weeks intervals when growth was available, quickly eliminated much of the bromegrass in the progenies and allowed appreciable quackgrass encroachment. There were few differences among progenies in survival and the treatment had to be abandoned after the second year of harvest.

In contrast, removal of the first cutting around the normal first anthesis date (June 12th) with two aftermath cuts during the remainder of the season allowed good bromegrass survival and much less of quackgrass encroachment. This reaction, which has repeatedly been observed in the past with this species, deserves serious consideration both in assessing the merit of this species for mixtures intended primarily for pasture and to possible changes in methods of selection to be used on the species for the isolation of clones and breeding of strains better adapted to this type of management. In comparative tests, both timothy and orchardgrass strains have responded better to early and frequent removal of forage than has bromegrass. Among the progenies tested, few gave indications of superior performance under both managements. Vigorous early growth and good regrowth capacity, two desirable attributes of bromegrass, have been the important selection criteria in the past and real progress has been achieved in their direction. These have limited value, however, unless the species can withstand the cutting management severity imposed by removal of the growth produced at an immature growth stage, which is required in order to produce high quality forage. Future selection and evaluation procedures with bromegrass should be directed to improve this deficiency.

Progeny evaluation of clones from second cycles of selection are still in progress for orchardgrass and timothy. In both species, medium to late maturity compared to common strains has been the first requisite of selection. Progress toward a late orchardgrass having both desirable vegetative characteristics and adequate seed producing capacity will be difficult to achieve. For this reason, new strains which are later than Pennlate in maturity (these are possible and very desirable from a forage standpoint) will need critical evaluation for seed production. Moving north from current areas of seed production which may be possible for late strains of other species is limited in orchardgrass because of its general level of cold tolerance and winter survival.

Regional progeny testing is in progress on second-cycle selections of timothy. Some of these clones show promise. Single-crosses between desirable clones have been produced and studied for several characters. Single-cross progenies have indicated that height and maturity heritability are very high with progeny means closely approximating the parental average. Performance of selfed lines for these and other characters shows considerable promise for strain synthesis in this species from either single clones or hybrids from a relatively few clones without pollination control.

Cooperative testing with the U.S.D.A. on single crosses of alfalfa clones from stations throughout the United States and on variety crosses and blends in alfalfa is being continued. Results at this station agree with the general findings that there has been no evidence of hybrid vigor in the variety crosses tested. Variety crosses have been found no better than blends of the same varieties and inferior to the best adapted of the variety parents.

The uniformity of single-crosses in alfalfa and the high heritability of certain clonal characters in crosses over a range of genotypes suggests considerable promise for strains derived from relatively small numbers of clones. A high frequency for certain characters in the strain population can be assured, an advantage in developing varieties for specific purposes and uses. The best single-crosses have not shown any decided yield advantage over the best adapted varieties although in general appearance and certain characters believed indicative of forage quality, they have been outstanding. Persistence and sustained production have not been fully evaluated.

In conjunction with other Northeastern states under regional project NE-28, investigations are now in progress on methods of variety synthesis in alfalfa. Seed of synthetics and hybrids from regionally tested superior clones is being produced under cage at this station and in California. Regional evaluation of these increases will begin in 1960.

Title: STRAIN TESTING AND BREEDING OF FORAGE PLANTS FOR NEW YORK STATE AND VICINITY WITH SPECIAL EMPHASIS ON PROBIEMS OF PRODUCTION DURING PERIODS OF MIDSUMMER DROUGHT.

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy, A. A. Johnson and J. T. Reid (Animal Husbandry) and H. A. MacDonald (Agronomy) cooperating.

Alfalfa: With improved seed supplies in prospect for the superior varieties: Narragansett, Vernal, DuPuits and Alfa, Ranger is no longer recommended for use in New York State. Ranger is inferior under New York conditions to the other varieties. Numerous trials under varied production conditions and managements have established the basis for choice among the four varieties now recommended. (1959 Annual Report, page 86).

The 1960 growing season in New York was unusually long and cool. Many areas had deficient rainfall during July and August. Killing frost in the fall was delayed nearly a month beyond normal, a factor which could potentially benefit or adversely affect producing stands depending on the management used and the type of alfalfa grown. Symptoms of, or resemblance to, bacterial wilt were unusually prevalent on susceptible varieties in trials which were in their third harvest season in 1960. This may have been connected with winter damage inflicted during 1958-59 when many new seedings survived even though older trials were killed outright by the severity of winter conditions.

As a result of extensive trial information, Cayuga, a 10-clone synthetic composed of clones selected in New York and widely tested in the northeast, was released for use in New York. This variety has a growth type conducive to fast recovery and high-yield potential under the 3-cuttings/season management system in which the Flemish strains have excelled. In tests to date, Cayuga has averaged about 1/2 ton lower yielding than DuPuits or Alfa in the first harvest season under this management; was equal or slightly superior in the second year, and 1/2 ton or more higher yielding than the Flemish strains in the third year of production.

Surviving stands indicate that in many cases, a fourth year of profitable production would be possible on Cayuga but not on the Flemish strains under the same conditions. Cayuga is wilt-resistant and is intended for use where slightly later maturity and greater persistence than found in the Flemish type is desirable, and under the growth conditions and management intensity currently being recommended for the Flemish strains.

Orchardgrass: An extensive series of trials comparing orchardgrass synthetics of different maturity with bromegrass and timothy under both 3 and 4 cuts/season management and in 3 associations: alone + nitrogen, with DuPuits alfalfa, and with Narragansett or Vernal alfalfa plus Ladino clover, has been completed.

Persistence of the associated alfalfa with the grass strains was a major factor in performance in the 2 legume associations. This was affected by the variety of the alfalfa, management imposed (3 vs 4 cuts), location of the trial (drainage conditions), and the differential competition furnished by the different grass strains and species. The contribution of the grass fraction in the mixture was much less with DuPuits than with Narragansett or Vernal combined with Ladino clover during the early harvest years; there was less difference between the grass contribution in the two as the alfalfa thinned and reseeded Ladino became a factor in mixture production. Where and when the alfalfa was the major contributor to yield, differences among the associated grass strains affected mixture composition but did not result in any large differences in average season yield. Where the strains were grown alone, however, or where the grass furnished a sizeable fraction of the mixture yield, the medium to early varieties and synthetics of orchardgrass showed a decided advantage in season production over late-maturing orchardgrass, bromegrass or timothy. Under the 4-cut management,

the addition of a small amount of Ladino to the mixture was of value both for producing forage in the second and third harvest year and for providing nitrogen for grass response as the alfalfa disappeared. Under 3-cut management, the effect of Ladino was less noticeable.

Medium-maturity orchardgrass synthetics gave the best over-all response to all conditions; they had the most ideal mixture of grass and legume, very little weed or quackgrass encroachment and gave highest yields. Bromegrass was inferior to the latest orchardgrasses under 4-cut management but better under 3-cut management; it was generally inferior in production to early and medium-maturity orchardgrasses. Timothy was better than bromegrass. For both bromegrass and timothy, legume stands were thicker than for orchardgrass because of less grass competition; on both species, however, quackgrass encroachment was heavy and detracted significantly. With the distinct relationship between maturity and production among orchardgrass synthetics and varieties, evaluation of forage quality differences appear necessary to establish the optimum maturity level for both high production and quality. Pennlate appears, at present, to be a desirable compromise maturity level.

Studies on varieties of orchardgrass, timothy, alfalfa and birdsfoot trefoil are in progress to follow the changes in yield and dry matter during May and June, and to correlate these changes with feeding trial information for both grass and legume strains and corresponding changes in both digestibility and intake. Comparisons of Common versus Essex timothy on different cutting dates in 1959 showed substantial differences in both digestibility and intake for forage cut on July 2nd, 1960. Lesser differences were also measured in comparisons between the varieties on June 8th and June 20th harvests. Both the higher feeding values and aftermath yield potentials resulting from early harvest are borne out in results but the data also show the advantage of late maturity in grass strains when harvest must necessarily be postponed.

Annual Forages:—Production trials and animal evaluation of a number of annual forage species are being continued. Foxtail, German, Japanese and Pearl millets; early and late sudangrasses; a range of forage sorghums including hybrids; and sorghum-sudan grass hybrids have been compared with drilled corns of different maturity. Some early forage sorghums and sorghum-sudangrass hybrids have shown promise for high yield, although none of the species has been found to equal drilled corn in tonnage produced under the same conditions. In digestion trials, it is apparent that the considerable range in maturity of the several species is closely correlated with their feeding value. Comparisons of all species using the same planting and harvest dates is unrealistic. Materials have now been collected to test feeding value on each of several dates rather than just one. The rapid maturity of some of the millets, the regrowth capacity of early sudangrass and the unique characteristics of several of the other species could be most important factors in certain annual crop situations and make them preferable to some of the other higher yielding annuals.

Title: BIRDSFOOT TREFOIL BREEDING AND GENETICS

Leaders: P. R. Henson and R. R. Seaney. (A.R.S., U.S.D.A. in cooperation with Cornell University, Ithaca, New York)

The amount of self-fertilization in the field occurring in four clones of birdsfoot trefoil, Lotus corniculatus, is shown in the following table:

Clone Number	Self-Compatibility in Terms of Seeds Set per Flower Pollinated	Percent Self-Fertilization Under Field Conditions
7-9	.16	1.7%
80-2	3.3	5.5
522-10	5.0	18.5
651	7.6	92.2

Self-and cross-progenies of these clones were identified by using positive HCN reaction as a dominant marker. In this experiment the amount of self-fertilization occurring in the field during 1960 was directly related to the self-compatibility of the clones.

Studies of plant morphology, pollen fertility, and meiosis have been used to confirm the identity of the following interspecific hybrids: L. uliginosus x L. filicaulis, L. uliginosus x L. divaricatus, L. uliginosus x L. tenuis, L. uliginosus x L. palustris, L. tenuis x L. palustris, L. tenuis x L. angustissimus.

Inbreeding in L. corniculatus has advanced to the selection and self-pollination of S_3 plants. Average self-fertility of S_2 plants appears to be higher than that of S_0 or S_1 plants. Two years results indicate a 60 percent reduction in dry weight yield from S_1 to the S_2 generation.

Study of the inheritance of seed coat mottling in L. tenuis has been completed. Data indicate single factor inheritance of seed coat mottling, with mottled dominant to non-mottled seed.

First year results indicate that small "micro-plots," either 3' x 5' or 4' x 8', are satisfactory for initial progeny testing of selected clones when only small amounts of seed are available. LSD values on this size of plots were about 0.5 tons per acre and coefficients of variation about 10 percent.

Title: FORAGE DISEASES

Leaders: L. Lopez-Matos and R. L. Millar

Collections made during a survey of 58 alfalfa or clover fields in 21 counties yielded a total of 61 isolates of Colletotrichum spp. The fungus was observed to be present in almost all the fields inspected.

Tests were made to determine the pathogenicity and virulence of the isolates on alfalfa and/or clover at different stages of development. It was found that when the isolates were tested on DuPuits seedlings at the cotyledonary stage in storage dishes, all isolates were pathogenic but differences in virulence were not readily determined. Similarly when the isolates were tested at the same stage on several alfalfa varieties grown in pots, all isolates were pathogenic; the isolates, however, could be placed in two groups depending on the symptoms that they caused. A few of the isolates produced a damping-off type of symptom. The majority, including an isolate of C. trifolii obtained from the American Type Culture Collection, produced lesioning on the leaves, stems and petioles but not the damping-off symptom. On clover, certain of the isolates were more virulent than the type culture of C. trifolii. A few of the isolates also were pathogenic on birdsfoot trefoil.

In tests involving plants that had been clipped once, the isolates readily attacked the young shoots. The virulence of some of the isolates was similar to that of the type culture whereas other isolates were much more virulent. In general the virulence of different isolates was the same as that obtained in tests made at the seedling stage.

A comparison of certain morphological characteristics of cultures of the isolates and of type cultures of C. trifolii, C. destructivum and C. graminicola is being made in connection with the pathogenicity tests.

In tests to determine the capacity of the fungus to overwinter under conditions at Ithaca, cultures were obtained from those portions of overwintered affected stems that were next to the crowns of alfalfa plants and also from lesions on new shoots that arose from the crown area. Observations made over a 1.5 year period have not provided any evidence that the fungus is seed-borne.

Title: THE EFFECT OF MOLYBDENUM, ALUMINUM AND MANGANESE ON THE GROWTH AND NODULATION OF BIRDSFOOT TREFOIL IN WATER CULTURE

Leaders: W. M. Kliewer, W. K. Kennedy, M. Alexander, and J. F. Hodgson

Greenhouse experiments were conducted to study the extent to which aluminum and manganese in the presence and absence of molybdenum are factors responsible for acid soil injury of birdsfoot trefoil grown in water culture lacking combined nitrogen. A 3 x 3 x 2 factorial arrangement of Al, Mn and Mo was used at concentrations of 0, 5 and 10 ppm Al; 0.5, 10 and 20 ppm Mn; and 0 and 0.1 ppm. Mo. A continuous flow technique with a separate source for aluminum solutions and for the basic nutrient solution was provided for each two-quart plastic container in which five plants were grown.

No significant response to Mo was found while both Al and Mn drastically affected the top and root yields and nodulation of birdsfoot trefoil (Table 6). A relative high level of Mn (10 ppm) in the absence of Al gave the best growth of birdsfoot trefoil, while 20 ppm Mn was toxic as indicated by the decrease in top and root yields and brown spotting of the leaves. The reason for the poor growth of birdsfoot trefoil at 0.5 ppm Mn in the absence of Al is not known.

Table 6. Influence of Al and Mn on the top yield of birdsfoot trefoil.

Aluminum conc.	Mn concentration		
	0.5 ppm	10 ppm	20 ppm
ppm			
0	0.94	8.19	3.17
5	1.04	0.38	0.24
10	0.40	0.38	0.21

All concentrations of Al were very detrimental to root and top growth and nodule formation. The presence of Al in the nutrient solution at all concentrations strongly inhibited any new root growth. A strong interaction of Al and Mn on top and root yields and on nodulation was found (Table 6). In the absence of Al, 10 ppm Mn increased top and root growth and the number of nodules per plant while when Al was present, top, root and new nodule formation was stopped. Manganese had comparatively little influence on the ability of birdsfoot trefoil to form new nodules.

Title: A STUDY OF THE SOURCES AND CONTROL OF NUTRITIONAL LOSSES OCCURRING DURING THE HARVESTING AND STORAGE OF HAY AND SILAGE

Leaders: M. J. Wright, W. K. Kennedy, and P. C. Kearney

Results of research completed are summarized herewith. (1959 Annual Report, page 88).

The rapid exclusion of air was found to be essential to success in making certain types of silage. It appeared that most forages had sufficient sugars to permit a satisfactory lactic acid fermentation if anaerobic conditions were promptly established, but that alfalfa had so small a supply that even a short period of aerobic respiration precluded the formation of enough lactic acid to lower the pH to a safe level. Pure grasses produced very satisfactory silages even after several hours of aerobic respiration.

Wilting to 65-70 percent moisture was effective in improving the quality of alfalfa silage, even though this extended the period of aerobic respiration. Laceration appeared to be little better than chopping.

Total hydrolyzable sugars in loosely-packed chopped forage were measured at intervals during the first 24 hours. When the level of total hydrolyzable sugars reached a level below about 15 percent of the dry matter, the resultant silage contained large amounts of butyric acid. The inhibition of lactic acid formation that accompanied a reduction in available sugar was in turn responsible for an acidity too small to prevent undesirable secondary fermentations; butyric acid, volatile bases, and total losses of dry matter increased accordingly.

Title: INFLUENCE OF DATE OF CUTTING, NITROGEN FERTILIZATION AND IRRIGATION UPON THE YIELD AND DIGESTIBILITY AND INTAKE OF DIFFERENT FORAGES BY RUMINANTS

Leaders: M. J. Wright and W. G. Monson (A.R.S., U.S.D.A.)

Plots of DuPuits or Narragansett alfalfa in mixture with Saratoga or Lincoln bromegrass, Essex or Common timothy, or commercial orchardgrass were established in 1960 for grazing to begin in 1961. Measurements of intake, digestibility, and persistence of each of these ten mixtures are planned over a three-year period. Nearly-mature or mature steers will be used as test animals.

Studies on nitrate accumulation and nitrate toxicity have been greatly expanded under a grant from the National Institutes of Health. Environmental influences and enzymatic conversions will receive major emphasis in studies on accumulation; physiological and pathological consequences of feeding nitrate to pregnant dairy heifers will be recorded in detail in studies of toxicity.

Title: MAXIMUM UTILIZATION OF FORAGES BY LIVESTOCK

Leaders: S. T. Slack, K. L. Turk, G. W. Trimberger, J. I. Miller, J. T. Reid, D. E. Hogue, W. G. Merrill, and J. K. Loosli (Department of Animal Husbandry) and W. K. Kennedy and H. A. MacDonald (Department of Agronomy)

In experiments with lactating cows, more milk per pound of dry matter intake has been obtained from wilted silage than from barndried hay (unheated air) cut at the same time. Experiments are in progress to determine the basic reasons for the differences in dry matter utilization.

Early-harvested forages are superior to late-harvested forages. Experiments are still in progress to determine the basic reasons for the differences in value between early-cut and late-cut forage. Feeding trials with yearling dairy heifers and lambs are being carried out for a second year. This experiment was designed to measure the quantitative differences in the hays due to intake, energy and protein. Because these trials are incomplete, preliminary conclusions cannot be drawn.

An experiment to compare the quality and feeding value of birdsfoot trefoil and a legume-grass mixture harvested for hay by different methods at different stages of maturity has been completed and the results will be reported during 1961. Milk production tended to follow date of harvest as has been shown for other legumes and grasses. Milk production of cows fed the trefoil hays was similar to those fed the grass-legume hays.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF FORAGE GRASSES

Leaders: J. L. Starling and R. W. Cleveland

Orchardgrass:—(1) Initial clonal evaluations were made in a 2500-plant source nursery established in 1959. Clones were rated for vigor, seed production, leafiness and disease resistance. (2) Fourteen Synthetic 1 and Synthetic 2 nurseries were maintained for seed production. (3) Second-year yield evaluations were made on restricted polycross progenies of clones in three broadcast trials. (4) Third-year yield evaluations were completed on seven experimental synthetics. (5) Pennlate breeders seed nursery was maintained and breeders seed produced. (6) Yield and morphological evaluations were made in a trial designed to study consistency of performance of Pennlate over several generations. In the initial year, similar performance was observed among generations and among restricted progenies of parental clones.

Bromegrass:--Broadcast plot seeding was made of restricted polycross progenies of clones included in two experimental synthetics. Synthetic nurseries were maintained.

Phalaris:--A five hundred plant nursery of F_2 generation of P. arundinacea x P. tuberosa was planted. Seed harvested was from BC_1 and BC_2 plants.

Third-year results were obtained at two locations of an experiment designed to evaluate critically new varieties and synthetics of several grasses when grown with and without legumes under several managements. Results to date indicate similar relative yield of varieties.

Variety Trials:--Tests including one or more species were conducted at eight different locations in the state.

Breeding work in orchardgrass indicates that advances in yield and quality are possible from clones currently under evaluation. Clones exhibiting good qualities have been identified in a new source nursery.

Study of advanced generations of Phalaris hybrids has revealed good material for selection for variety development if adequate fertility can be obtained.

All work in orchardgrass described above will continue. Superior clones in source nursery (A-1) will be vegetatively increased and transplanted to a replicated nursery for more complete evaluation and for production of seed for plot testing.

Yield evaluation will be made in the bromegrass trial. Plants in Phalaris F_2 nursery will be evaluated and seed harvested. Variety trials will be harvested.

Title: CYTOGENETICS OF FORAGE CROP SPECIES AND INTERSPECIFIC HYBRIDS

Leaders: J. L. Starling and R. W. Cleveland

Studies of interspecific hybrids between clover species are being conducted. The interspecific hybrid, Trifolium pratense X T. diffusum was obtained and backcrossed to T. pratense. Crosses were made between T. pratense and T. hirtum, T. pallidum, T. globosum, T. medium and T. radiosum. Seedlings which may be interspecific hybrids have been obtained from all crosses.

Cytogenetic study of the backcross 1 and 2 generations of the interspecific hybrid, Phalaris arundinacea X P. tuberosa was completed. The BC-1 plants examined varied in chromosome number and were as irregular meiotically as the F_1 parental hybrids. Thirty-five chromosome BC_2 plants were more fertile and meiotically more stable than the BC_1.

A search for haploid seedlings in Phalaris tuberosa was initiated. At least one haploid plant was identified. Its chromosome number was doubled for comparisons with normal strains of tuberosa.

A study was initiated to determine the causes of reciprocal differences in crossability of Phalaris arundinacea and P. tuberosa. Pollen tube growth in reciprocal crosses has been studied using ultra-violet light. Material has been collected for embryo sac development study.

Preliminary results in Trifolium hybridization work indicate that the cross inhibiting barriers between several species may be overcome via embryo excision. The interspecific hybrid produced may be useful in clover breeding.

Cytological study of the early backcross generations of the Phalaris arundinacea X P. tuberosa hybrid showed that the meiotic irregularities characteristic of the F_1 hybrid occur with high frequency in the backcross generations. High levels of fertility are not likely to be restored in early backcross generations.

Cytological studies of meiosis will be made for each Trifolium interspecific hybrids; where possible, backcrosses will be made to T. pratense.

Meiosis will be studied in the Phalaris tuberosa haploid, the doubled line and in progenies from crosses with normal strains of P. tuberosa. Search for haploids will continue.

The study of cross-inhibiting mechanisms between P. tuberosa and P. arundinacea will continue.

Title: THE INTRODUCTION AND EVALUATION OF FORAGE CROPS

Leaders: J. L. Starling and R. W. Cleveland

Two nurseries of introductions established in 1959 and 1960 were maintained and evaluated for characteristics valuable in breeding programs. Seed was harvested from plots established from composites of seed harvested from individual accessions planted in 1957 and 1958. Similar composite plantings were made for the following species: alfalfa, birdsfoot trefoil, red clover, zig-zag clover, bromegrass, bluegrass, meadow foxtail, orchardgrass, red fescue, Reed canarygrass, tall fescue and timothy.

New accessions obtained from three Regional Plant Introduction Stations were planted in rows with check varieties. The 1960 planting contains the following species: (No. accessions in parenthesis)

Trifolium pratense (25), T. repens (230), T. fragiferum (5), T. ambiguum (3), Lotus sp. (51), Medicago sp. (33), Bromus inermis (8), Pheleum pratense (25), Dactylis glomerata (61), Festuca rubra (2), F. arundinacea (44), F. elatior (12), Phalaris arundinacea (21), P. tuberosa (52), P. brachystachys (18), P. paradoxa (2), Alopecurus sp. (16), Agrostis sp. (7), Arrhenatherum elatius (39), Lolium perenne (5), and Poa pratense (8).

Most accessions are not superior to current varieties in general agronomic value. Many, however, possess specific qualities which would be desirable in adapted varieties. The pooling of germ plasm from the diverse sources represented by these accessions should provide excellent source material for breeding programs.

Seed will be harvested from the thirteen composite nurseries and from introductions in the 1959 and 1960 row plantings. Accessions planted in these years will be evaluated. New accessions will be obtained from the Plant Introduction Stations for row plantings.

Title: THE GENETICS AND IMPROVEMENT OF ALFALFA (Medicago sativa L.)

Leaders: R. W. Cleveland and J. L. Starling

Two broadcast plot experiments established in 1959 were evaluated for yield in 1960. One trial is designed to evaluate varieties and commercial seed blends. The other includes synthesized blends with two-varietal components. The latter trial is designed to evaluate alfalfa variety blends formulated with different seeding rates. Two additional harvest years will be required to complete the results.

The breeding of creeping-rooted alfalfas for pasture purposes was continued. Self-pollination progenies of creeping-rooted parents were established in spaced plants. Creeping-rooted selected clones were also used as parents in crosses to non-creeping representative plants from standard (hay-type) alfalfa varieties. F_1 plants will be studied in a spaced-planted field trial to evaluate creeping habit and other characteristics. The better creeping parents will be chosen for future breeding studies.

Alfalfa variety trials previously established at Ligonier and Centre Hall, Pa., were harvested for yield in 1960. New alfalfa variety trials were established at 4 locations.

Genetic studies consisted of the inheritance of ovule number, pollen-tube growth, various leaf abnormalities, and flower color of diploid alfalfas ($2n = 16$). These studies are being carried on by Mr. D. K. Barnes. Segregating generations for the several separate studies were grown in the greenhouse, classified, and appropriate additional selfed and crossed generations produced.

Results of variety trials are useful in recommending use of varieties in Pennsylvania. Several new alfalfa varieties are becoming available to farmers of this state; many of these are adapted to growth in this area, others are not.

All breeding studies and variety trials outlined above will be continued in 1961. New alfalfa variety trials will be established at several locations.

Title: THE GENETICS AND IMPROVEMENT OF BIRDSFOOT TREFOIL (Lotus corniculatus L.)

Leaders: R. W. Cleveland and J. L. Starling

Surviving plants from several ice-sheet damaged plantings (broadcast variety trials and progeny evaluation trials) were maintained in a space-planted nursery in 1960. Survival of plants in this nursery was only fair, with many plants failing after transplantation. It is expected that the final survivors will have a higher than normal level of winter-hardiness. Seed production in this planting was poor in 1960, and seed harvest was postponed until 1961.

Seed production nurseries of four experimental synthetics (formulated in 1956) were maintained for the preservation of the genetic material. The evaluation of these synthetics is not yet complete.

A manuscript was prepared presenting summaries of forage yields of birdsfoot trefoil varieties. Trials were conducted for several years at several locations in Pennsylvania prior to 1960. Viking and Mansfield trefoils proved to be the highest yielding among varieties which are currently available to farmers.

The results of variety trials are of prime importance in formulating variety recommendations. Birdsfoot trefoil has been of increasing interest to farmers in Pennsylvania, and the results of variety trials have pointed out the varieties best adapted and highest yielding in Pennsylvania.

Selected clones will be maintained, and seed produced from them for progeny evaluation trials. New variety trials may be established if feasible.

Title: THE GENETICS AND IMPROVEMENT OF RED CLOVER

Leaders: R. W. Cleveland and J. L. Starling

Broadcast plot variety trials were established at four locations in Pennsylvania in 1960 and will be harvested for the first year in 1961. There were no yield determinations in 1960.

An effort to transfer resistance to Northern Anthracnose (a disease caused by Kabatiella caulivora) into Pennscott red clover is in progress. The source of resistance is plant material selected from Lakeland stocks. The first backcross to Pennscott has been produced, and BC_1 plants are being intercrossed prior to screening for resistance and further backcrossing.

Inheritance of resistance to Northern Anthracnose is also being studied. The F_1 (Pennscott x Lakeland selections) was grown, and an F_2 and testcross have been produced. F_1's and F_2's have also been produced using Kentucky self-fertile lines as susceptible parents.

Red Clover is second in importance only to alfalfa as a forage legume in Pennsylvania and new varieties are thus of great potential value to agriculture of this state. No new varieties superior to Pennscott red clover have yet been tested, although the Maryland strain Chesapeake is well adapted and yields about the same as Pennscott.

The new variety trials will be harvested for yield in 1961. Additional variety trials will be established. The breeding program outlined above will be continued.

Title: FORAGE INSECTS

Leaders: N. D. Blackburn and C. J. McKown

The alfalfa weevil continued to be the major forage insect pest in Pennsylvania during 1960. Larval populations reached economic thresholds in many fields of Central Pennsylvania for the first time since the insect was found in the southeastern part of the State in 1951. All available evidence indicates that injury will be widespread and severe during the coming season.

The establishment of a zero tolerance early in 1960 for heptachlor and its breakdown product, heptachlor epoxide, on alfalfa prevented use of the most effective material thus far developed for control of the alfalfa weevil. Consequently, research was directed towards both the evaluation of other effective control chemicals as well as towards possible modifications in the use of heptachlor which would leave no residues on the hay or other products.

Experiments indicated that alternate materials, such as methoxychlor and malathion cleared for use on forage crops, were only temporarily effective in single applications for control of the larvae. Methoxychlor applied at the single applications of larval population development provided fair control, but by this time foliage had been damaged considerably.

Heptachlor, applied in separate experiments as both granulated and emulsifiable formulations early in the spring at the rate of 1 lb. (a.i.) per acre, provided 95 percent control of the larvae with residues of 0.1 ppm of heptachlor and heptachlor epoxide on the green hay at harvest.

In an effort to effect control of the adult insect during the fall months and at the same time avoid measurable residues on the hay at harvest the following spring, a number of potential control chemicals were applied to a series of experimental plots during October and November. These materials included heptachlor, dieldrin, aldrin, chlordane, and an experimental material as both granulated and emulsifiable formulations at three application rates for each insecticide and each formulation. Data on population control and residues will be obtained in 1961.

Some evidence was obtained that the alfalfa weevil may develop a partial second generation in Central Pennsylvania. Larval population levels during August and September were many times higher than had been noted previously at this time of the year and approximately one-half those encountered in southern counties during the first generation in the spring.

Experiments with dimethoate for control of haustellate insects on second-crop alfalfa showed it to be almost as effective as methoxychlor in reducing leaf hopper populations for a period of 10-15 days and much superior to methoxychlor in the control of aphids. Dimethate, at present, is not cleared for use on alfalfa.

Title: MAINTENANCE FERTILIZATION OF GRASSLANDS IN PENNSYLVANIA

Leader: L. F. Marriott

NPK topdressings on common orchardgrass were continued in the fifth year on Berks shaly silt loam and in the fourth year on Bucks silt loam, both sites in the southeastern portion of the state. The orchardgrass fertilized with adequate PK and with 0, 50, 100, and 200 pounds of nitrogen per acre produced 2960, 3580, 4100, and 5320 pounds dry matter on the Berks soil and 2560, 3580, 5260, and 7200 pounds dry matter on the Bucks soil. Better moisture accounted for the higher yields at the higher N rates on the Bucks soil.

Omission of K where 200 pounds of N has been applied annually has resulted in a loss of stand and a reduction in yield from 5320 to 2420 pounds dry matter on the Berks soil. The reduction on the Bucks soil was from 7200 to 4020 pounds dry matter per acre. Omission of P has resulted in yield reductions of only 5 to 10 percent.

Title: MANAGEMENT OF PERENNIAL FORAGE GRASSES IN PENNSYLVANIA

Leaders: J. B. Washko, J. R. Mitchell

When 4 grasses, Potomac and Pennlate orchardgrasses, Reed canarygrass and Climax timothy, fertilized with 100 and 300 pounds of nitrogen and P and K at a constant level, were harvested at 4 stages of maturity and 2 clipping heights, the results were as follows:—Potomac orchardgrass reached the early head, early bloom and past bloom stages of maturity approximately one week prior to Pennlate orchardgrass and Reed canarygrass and three weeks earlier than Climax timothy. Removal of the first harvest of Reed canary and timothy stimulated vigorous aftermath growth by these species and the production of 2 and 1 tons of dry matter respectively at the high N level. Dry matter and T.D.N. production varied with stage of maturity at harvest. Highest dry matter yields and T.D.N. production were obtained at the early bloom stage of harvest except for timothy. Both Climax timothy and Reed canary produced greater yields of dry matter and T.D.N. when harvested at the pre-joint stage than the two orchardgrass varieties.

Harvesting the first aftermath at either 1 1/2 or 3 1/2 inches did not influence total seasonal yield. T.D.N. production decreased up to 600 lbs./A. when the first harvest was delayed until past bloom as compared with harvesting at the pre-joint stage.

Title: PRODUCTIVITY AND LONGEVITY OF RENOVATED PASTURES

Leaders: J. B. Washko and J. K. Pasto

During 1960 investigations on the feasibility of stockpiling pure stands of birdsfoot trefoil were continued. The following grazing management treatments were imposed on a pure stand of Empire birdsfoot trefoil:— (a) Grazed in rotation (3 times) beginning May 24 (b) Grazed June 1, July 15 and September 1 (c) Grazed June 15 and August 1 (d) Grazed July 1 and August 15 (e) Grazed July 15 and September 1.

Measurements were made to determine yield, seasonal distribution of forage, protein, fiber and total digestible nutrients of the forage for each treatment. Grazeable forage was removed by dry cows and heifers.

The highest total seasonal yield was obtained when the trefoil forage was stockpiled until June 1. Only minor differences in seasonal production were apparent under rotational grazing and stockpiling until June 15 as compared with initiation of grazing on June 1. However, marked reductions in total yields were obtained when forage was stockpiled until July 1 and July 15.

The two grazing treatments which were found to be superior from the standpoint of better seasonal distribution of forage were those of rotational grazing and initiation of grazing on June 1. The rotational grazing paddocks furnished .71 tons of dry forage on May 24, .53 tons on June 27 and .87 tons on August 8. Those grazed for the first time on June 1 provided 1.05 tons of dry matter on that date, 1.08 tons on July 15 and .23 tons on September 1 after a severe August drought. It is of interest to note that paddocks which initially furnished one ton of pasturage on June 1 had produced another ton by July 15, whereas delaying initial grazing until July 15 resulted in the production of only 1.5 tons of dry matter by that date.

Total seasonal production of crude protein was approximately .5 tons per acre for the paddocks grazed in rotation and those stockpiled until June 1. Those paddocks stockpiled until June 15 produced about .4 tons of crude protein per acre, whereas about .3 tons was produced under the remaining two grazing systems. The reduction of 200 to 400 pounds of crude protein per acre may be indicative of the consequences of stockpiling beyond June 1.

Although fiber content increased with each delay in initiation of the first grazing, no palatability problems as indicated by animal acceptance were encountered.

Title: EVALUATION OF SORGHUMS, SUDANGRASS AND MILLETS FOR FEED PRODUCTION

Leaders: J. B. Washko and A. L. Haskins

Greenleaf was the highest yielding sudangrass at University Park, whereas Piper was most productive at Landisville under a 2-cut hay management system. Under grazing conditions at University Park yields of Piper and Greenleaf were similar. Of the 3 sudangrass varieties tested Ga. 337 yielded poorest at both locations. Gahi pearl millet was more productive than common pearl millet. Sorghum almum was one of the lowest yielding species at both locations.

Of the sudangrass-sorghum hybrids the two commercial hybrids, Volkman and DeKalb SX-11, were most productive of forage at both locations. The Texas sudan-sorghum hybrids which looked so promising in 1959 did not perform on a par with the two commercial hybrids mentioned.

The 3 highest yielding forage sorghums at both locations were Asgrow Silo King, F.S. 301F hybrid, and NK-3065. These forage sorghums outyielded hybrid corn at University Park but not at Landisville. This can probably be attributed to the drought that prevailed at University Park during August but did not extend to Landisville.

Yields of corn planted at high populations increased as plant populations increased from 20,000 to 100,000 plants per acre. At 50,000 and 100,000 plants per acre yield differences were minor when 7" and 14" row spacings were compared. Lodging became a serious harvesting problem on the 100,000 plant population plots. The 1960 drought limited dry matter production of the heavy population corn for silage to a range of 4.0 to 5.5 tons of dry matter per acre.

Title: UTILIZATION OF FORAGE BY BEEF CATTLE

Leaders: J. B. Washko, P. J. Phillips, G. R. Kean, R. C. Miller, J. K. Pasto, A. L. Haskins, and J. H. Ziegler

When 192 grade yearling beef steers, stocked at .87 acres per animal unit, were grazed on legume-grass and nitrogen fertilized grass swards for 209 days with and without grain feeding (5 lbs. of corn and oats with 1 lb. of protein supplement) and stilbestrol implantation, the following results were obtained: the N-fertilized grass swards produced from 4.66 to 4.79 tons of dry matter and the legume-grass swards from 3.30 to 3.91 tons per acre. Beef gains in lbs. per acre were as follows: on N fertilized grass alone 326, N fertilized grass with grain feeding 396, legume-grass alone 352 and legume-grass with grain 382. Stilbestrol implantation increased gains significantly. Grain feeding increased dressing percentage and conformation and quality scores whereas stilbestrol had no apparent effect on these factors. Economic analyses of cost of beef production under these various conditions is in progress.

Title: EVALUATION OF GRASSES AND LEGUMES FOR HAY GRASS SILAGE AND PASTURE FOR DAIRY COWS

Leaders: P. S. Williams, J. B. Washko and A. L. Haskins

Piper sudangrass was grazed in rotation by dairy cows under two nitrogen fertilization practices, 200 pounds of N per acre plowed down as a single application and 200 pounds applied in 4 splits of 50 lbs. each. Greenleaf sudan was also grazed under the single 200 pound N application.

Highest dry matter production, T.D.N. production and carrying capacity per acre were obtained when the nitrogen was applied in four 50-pound split applications. N in split applications produced .4 tons more of dry matter, 721 pounds more of T.D.N. and 42 more cow days of grazing than when all the nitrogen was applied at once. The chemical composition of the forage as indicated by protein and T.D.N. content, however, was higher when all the nitrogen was applied at one time.

The greenleaf variety of sudangrass yielded approximately the same as the Piper variety. Greenleaf, however, appeared to be somewhat later in maturity than Piper and was less vigorous at the seedling stage. It offers promise of spreading the season of grazing or harvest season.

Title: PASTURE FOR YOUNG HOLSTEIN CALVES

Leader: E. M. Kesler

The feasibility of maintaining young Holstein calves on pasture was tested during three successive grazing seasons, 1958 to 1960. Young calves, male and female, were raised to 6 weeks of age on mile replacer, grain and hay. Subsequently, eight calves were maintained, during each season, on pasture until 20 weeks of age, and a control group of eight remained under barn feeding conditions. The pasture consisted of two plots, one of common orchardgrass mixed with bluegrass, the other an alfalfa-mixed grass aftermath. The plots were grazed in rotation. No supplemental feed was offered pasture-fed calves except 3 pounds of calf starter daily. Controls were fed good quality ad libitum and 3 pounds of starter. The animals fed pasture grew as well as controls. Gains in body weight between 6 and 12 weeks of age averaged 60.1 lb. for calves fed pasture and 64.2 lb. for controls (3-year averages, 24 calves per treatment). Corresponding gains in body weight between 6 and 20 weeks of age were: pasture-fed, 157.1 lb., controls, 149.7 lb. These gains were not statistically different. Average gains in height at withers between 6 and 20 weeks were 14.3 and 12.7 inches, respectively for pasture-fed and control calves. An attempt to measure intake of grazed forage by the Cr_2O_3-plant chromogens technique indicated that calves approximately 16 weeks of age were consuming an average of 8.5 lb. of forage dry matter daily.

Title: FORAGE CROP ESTABLISHMENT STUDIES

Leader: R. C. Wakefield

Experiments were initiated to study the effects of intra-species and weed competition on the establishment of legumes. Results during the seeding year showed that plants grown under weed-free conditions and low legume populations produced more top and root growth than where excessive competition was present from weeds or other plants of the same species. Effects of over-wintering and growth during the second year will be measured.

Title: INSECT AND OTHER ALLIED PESTS OF FORAGE CROPS AND THEIR CONTROL UNDER RHODE ISLAND CONDITIONS

Leader: T. W. Kerr

A survey of insects in pure stands of alfalfa, timothy, bromegrass and orchardgrass continued to show aphids, leafhoppers, lepidopterous larvae and lygus bugs to be most prevalent. Leafhoppers were particularly abundant and favored grasses, especially bromegrass, over alfalfa. The most abundant leafhopper species were Macrosteles fascifrons (Stal.), Graminella nigrifrons (Forbes) and Endria inimica (Say). Three times as many leafhoppers were collected from plots of grass clipped weekly than from those allowed to grow to maturity. Also, leafhoppers were collected in greater numbers from newly seeded grass plots than from older stands. The treatment of all three grasses with heptachlor resulted in an immediate reduction in the numbers of some leafhopper species followed by a substantial increase several weeks later.

Title: INVESTIGATION OF THE VIRUS RELATIONSHIP BETWEEN PIERCE'S DISEASE OF GRAPE AND ALFALFA "DWARF" IN RHODE ISLAND

Leader: Walter C. Mueller

Alfalfa plants taken from fields have been shown to contain the "dwarf" and mosaic viruses. Clover plants are also infected with alfalfa mosaic and several, as yet, unidentified viruses.

Title: CONTROL OF DISEASES OF FORAGE CROPS; ROOT ROT OF ALFALFA

Leader: F. L. Howard

Fusarium oxysporum appears to be the usual initial inciting agent of the alfalfa root rot syndrome in Rhode Island. This fungus is almost solely present in the discolored vascular tissues of young, naturally infected plants. Also, typical symptoms have been produced upon inoculation of healthy plants. An opportunity to determine the relation between plant age and degree of infection arose when the Agronomy Department made available plants from plots seeded May 20, 1960, May 8, 1959 and August 1958. Since previous observations had indicated that an apparent optimum period of infection occurred during the late fall, one series was dug and examined in mid-October and another series dug and examined in mid-November.

The percent of plants attacked increased during the month elapsing between examinations. Of the plants sown May 20, 1960, infection increased from 15 percent in October to 33 percent in November. The one- and two-year old plants did not show such a great increase in the average number of attacked. However, the percent diseased was very high. In those sown May 8, 1959 the number diseased increased from 77 percent to 84.7 percent, and those planted August, 1958 increased from 95 percent to 100 percent. The remaining plants were scattered in the plots, especially in the oldest planting. The fungus probably killed many plants during their first and second years of growth.

All three age groups showed an increase in the "degree of infection" index (0-10) from October to November, especially the two-year old plants whose index doubled from 2.7 to 5.45. The plants from seed sown in May, 1960 and May, 1959 had a much smaller increase of diseased tissue, 2.09 to 2.63 and 2.0 to 2.25 respectively. It is noticeable that the plants from 1959 had a somewhat lower index than those from 1960, in spite of the much higher percent of diseased plants.

The plants were examined by splitting the roots longitudinally. Discoloration was always found scattered in the vascular tissue, and often extended through the whole root. The color was usually brown, varying from light brown to almost black. The diseased tissue could be picked out as thread-like strands. In some, rot in the crown appeared to start at the base of dead stems. Most of the two-year-old plants, when checked in November, had a very severe rot in the crown, sometimes extending 2 to 3 inches downwards and leaving just a thin layer of the outer part of the root sound. This was very seldom seen in October.

Observations were made on the development of root rot in seedlings in conjunction with an Agronomy Department study on legume seedling establishment. Notes were taken on vascular discoloration in plants dug October 4, 1960 from spring seedings. Both number of infected plants and degree of tissue involvement (index 0-10) were recorded.

As the rate of seeding increased, the percent of diseased roots decreased where weeds were controlled. In the check plots, the number of diseased roots increased as the seeding rate increased. The unweeded check plots averaged 42.9 percent diseased plants with an involvement index of 2.08.

Studies are underway on the time, place and method of entrance of the fusarial hyphae into the alfalfa roots and also on modification of the root metabolism in order to increase resistance to attack.

Title: NITROGEN FERTILIZERS FOR GRASS AND GRASS-LEGUME FORAGE MIXTURES

Leaders: R. C. Wakefield, J. W. Cobble and J. B. Smith

Residual effects of nitrogen fertilizer treatments were measured by rating the vigor of stands and harvesting yields from plots previously treated (1959 Annual Report, page 104).

Stands of orchardgrass and bromegrass were not noticeably thinned by treatments. Bromegrass plots were uniformly weedy while orchardgrass was weed-free. Residual nitrogen was present in ureaform plots treated at high rates (300 lbs. N/A) and was reflected in higher yields from these plots. Plots that had received large single applications of nitrogen as ammonium nitrate were somewhat less vigorous and yielded less forage than check plots.

In grazing trials, nitrogen-fertilized orchardgrass gave greater carrying capacity and forage was consumed in greater quantities by dairy heifers than orchard-Ladino. Weight and size gains were similar for the two types of pastures.

VERMONT

Title: IRON OXIDATION PROXIMATE TO PLANT ROOTS

Leaders: R. J. Bartlett and J. Bornstein

In connection with study of soil drainage problems, investigations have been underway concerning some basic crop-soil-water-air interrelationships. Because of its sensitivity to changes in oxidation-reduction changes commonly occurring in soils, iron was used as an indicator of the aeration conditions in the root zones of several forage species. Oxidation was demonstrated directly in true solutions and indirectly in soil by a method involving extraction of ferrous iron. All plants studied exhibited a tendency to effect an improvement in the oxidative situation in their rhizospheres.

Among the crops studied, Reed canarygrass, timothy and trefoil were consistently among the most successful oxidizers, while alfalfa was at the bottom of the list. The oxidizing power of both red clover and bromegrass was relatively low but greater than that of alfalfa. Alsike produced conflicting high and low values.

In general, the poor oxidizers took up the most iron into their tops, while the efficient oxidizers were the iron excluders. Perhaps solubilities of other toxic substances formed under waterlogging in the field also are lessened in the region of improved oxidation proximate to the roots of moisture tolerant forage species.

Title: AGRONOMIC EVALUATION OF NEW EXPERIMENTAL LINES AND HYBRIDS OF BIRDSFOOT TREFOIL

Leaders: T. R. Flanagan and F. Laing

A. Sixth cycle of selection of hybrids of L. corniculatus and L. tenuis 4X was completed. Limited additional selections are planned for superior agronomic types. Greenhouse studies are being continued on the development of new hybrids including the introduction of L. uliginosis germ plasm.

B. Replicated plot tests of 14 selected hybrid lines in two locations showed first year harvest superiority of 9 lines over Mansfield and Viking, with one hybrid line yielding 75 percent more than Viking. Polycross seed for further testing is being produced from superior lines. Further yield studies will be made.

Title: FORAGE CROPS INSECTS, THEIR RELATIVE IMPORTANCE AND CONTROL

Leader: George B. MacCollom

Studies in 1960 confirmed previous investigations (1959 Annual Report, page 106) that timing of insecticidal applications to birdsfoot trefoil grown for seed is not critical, providing the applications are made within 600 + 200 degree days (50°F. base). This period ranged from a minimum of 19 days in 1959-60 to a maximum of 26 days in 1958.

Insect population studies on six seed fields showed a definite correlation between the Mirid population present, and the amount of seed yielded.

Title: WHEY AS A FERTILIZER FOR PASTURE GRASSES

Leader: A. R. Midgley

With increasing production of cottage cheese, the disposal of the by-product whey becomes more important. Because of its high sugar content it produces "dead streams" when whey is run into them.

Whey can be considered a very low grade fertilizer when added to soils. However, the high sugar content causes problems in soils if high rates are used at one time. One acre inch of whey (about 226,000 pounds) contains the following amount of plant nutrients:

The Fertilizer Value of an Acre Inch of Whey

Chemical	Pounds per acre inch
$CaCO_3$	282
N	316
P_2O_5	204
K_2O	487

However, since most of the nutrients are in the organic form, and since relatively small amounts should be applied at one time (about 1/10 to 2/10 acre inch per application) the effect of whey on forage production is not very obvious or quickly obtained. Grasses are more tolerant to whey application than most legumes.

Title: THE INFLUENCE OF THERMOPERIODS AND LIGHT ENERGY ON THE PRODUCTION OF THE SEXUAL STAGE OF SCLEROTINIA TRIFOLIORUM

Leaders: Thomas Sproston and Larry Laber

Work is progressing on the development of an action spectrum for the pigment receiving light energy necessary for maturation of the fungus. Monochromatic filters are used to screen wavelengths necessary for production of apothecia. Cultures of the fungus have been running out so to speak in their production of fundaments. They are being revived by heterocaryosis using a new technique involving anastomosis of mycelium. The fungus seems to revert to the asexual stage unless revived by heterocaryosis.

Title: SHEEP GRAZING TRIALS WITH BIRDSFOOT TREFOIL

Leaders: G. M. Wood and K. E. Varney

As an expansion of a simulated grazing experiment (1959 Annual Report, page 107) several of the trefoils formely tested were seeded in approximately 1/10 acre plots and subject to severe and rotational grazing by sheep. Yields were determined by pasture cages. Polyploid narrowleaf was highest yielding when grazed severely with Empire a close second. Under a rotational grazing system Empire looked best. Other trefoils in the test included California narrowleaf, Mansfield and an experimental hybrid.

WEST VIRGINIA

Title: SUDANGRASS FERTILITY AND CUTTING MANAGEMENT TRIAL

Leaders: G. A. Jung and W. T. Carlson

Piper sudangrass was grown under five levels of nitrogen and five cutting managements. Significant differences in yields were observed for all levels of nitrogen and all stages of growth. The digestibility, protein and prussic acid content of the samples will be determined.

Title: INTERSPECIFIC CROSSES AND CYTOLOGICAL INVESTIGATIONS IN THE GENUS MEDICAGO

Leaders: D. Martz and V. Ulrich

Investigations into species cross-compatibility, genome relationships and thereby species relationships were conducted within the genus Medicago. Crosses within as well as between the bur clover and the turban group were unsuccessful. Crosses involving these species and Medicago sativa groups were also unsuccessful. Standard 57 percent ethanol solutions were used for emasculations. It is suspected that this resulted in damage to the ovary and ovules of some species and may in part account for cross incompatibility.

Thirty-seven hybrids were obtained from M. hemicycla (2n = 32) x M. sativa (2n = 32) and two from M. hemicycla x M. glutinosa. Reciprocal crosses of these were made but only those having M. hemicycla as female parents produced seed.

Analyses of meiotic behavior and genome relationships are being conducted for parent species and hybrids.

Title: RATE AND TIME OF APPLICATION OF POTASH FERTILIZER IN RELATION TO YIELD AND LONGEVITY OF ALFALFA STANDS

Leaders: C. D. Reese and G. G. Pohlman

Initial seedings were made in three areas in the fall of 1960. Differential potassium treatments to give 200, 300 and 400 pounds per acre of available potassium will be started this spring. Applications will be made at 4 times - (1) in early spring, (2) after 1st cutting, (3) after second cutting and (4) after third cutting. Two split applications will also be compared.

Soil samples will be taken from and stand counts made on 50 alfalfa demonstration plots established in 1959 to measure effect of potash on longevity of alfalfa.

Title: CEREAL AND FORAGE CROP PESTS; THEIR DISTRIBUTION, INCIDENCE, AND CONTROL IN WEST VIRGINIA

Leader: C. K. Dorsey

Main emphasis is being devoted to control studies of the alfalfa weevil. Spray (14 different treatments) and granular (10 different treatments) formulations are being used. Comparative effectiveness of spring and fall applications of these materials and formulations is being studied.

Title: THE PERFORMANCE OF SEVERAL ALFALFA VARIETIES GROWN UNDER DIFFERENT CLIMATIC CONDITIONS, WITH EMPHASIS ON THE INFLUENCE OF FALL CUTTING

Leaders: G. A. Jung and W. T. Carlson

Eight locations were chosen in 1959 for testing six alfalfa varieties for persistence and relative performance under a wide range of climatic conditions in West Virginia. Four fall cutting dates were selected to study the effect of time of cutting at each location. The F values obtained upon the analysis of variance of 1960 yields from all eight locations for (1) Location, (2) Varieties, and (3) the Variety x Location Interaction exceeded the .005 level of significance; the F value for the Variety x Fall Cutting Management exceeded the .01 level of significance; the F values for (1) Fall Cutting Management, (2) the Location x Fall Cutting Management interaction and (3) the Variety x Location x Fall Cutting Management were lower than values denoting the .05 level of significance.

Field cured yields (15 percent moisture) for the first harvest year at all locations ranged from 6.48 tons/acre to 1.17 tons/acre. Maximum differences in yields between varieties at any one location varied from 0.67 to 2.32 tons/acre; maximum differences in yields between the fall cutting management of all varieties at any one location ranged from 0.23 to 1.56 tons/acre. The least difference due to fall cutting management for any one variety was 0.30 tons/acre and the greatest difference for any one variety was 2.07 tons/acre. The greatest uniformity and least uniformity just indicated (0.30 vs. 2.07 T/A) were obtained from the same variety at different locations in West Virginia.

Title: BIOCHEMICAL STUDIES IN COLD RESISTANCE OF ALFALFA

Leaders: G. A. Jung and W. T. Carlson

Two varieties of alfalfa were planted April 25, 1960. Cold resistance measurements of various plant sections were made at selected intervals beginning July 20 by means of the method derived by Dexter et al. Additional plants were collected at each interval and stored in a deep freeze for subsequent biochemical analysis.

USEFUL TECHNIQUES

U. S. REGIONAL PASTURE RESEARCH LABORATORY

Simple Procedure for the Estimation of the Alcohol-insoluble Fraction of Forages

This procedure measures the portion of a forage which is insoluble in 80 percent ethyl alcohol, on an ash-free basis, and exclusive of fructosan and starch. These last two substances, being almost completely digestible by ruminants, are by this procedure relegated to the alcohol-soluble portion along with other highly digestible substances.

Place a fat-free sample (residue of either an ether extraction or of a benzene-alcohol extraction) in a 250 ml. beaker. Add 40 ml. of a 1 percent oxalic acid solution, bring to a boil on an electric hot plate and boil gently for 5 minutes. If necessary, wash down the sides of the beaker with a minimum amount of water and add water to replace that lost by evaporation. Allow to cool partially, add 160 ml. of 95 percent alcohol, stir, and allow to settle several hours or overnight. Add a small amount of celite (this is optional), stir and allow to settle. Pour the supernatant liquid through a Gooch crucible containing an asbestos mat. Add about 50 ml. of 80 percent alcohol to the residue, warm, complete the filtration, and wash with warm 80 percent alcohol. Dry in a vacuum oven, cool in a desiccator, and weigh. Ignite in a muffle furnace at about 600°C, cool, and weigh, and record the loss in weight on ignition.

By this determination and one for ether extract the total organic matter may be divided into three fractions, ether-soluble, alcohol-soluble, and alcohol-insoluble.

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