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THIRTIETH ANNUAL REPORT

of

↙
Pasture Research

✓ in the

Northeastern United States
University Park, Pennsylvania

1966

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INTRODUCTION

This Report, the thirtieth of the series, is intended for the use of personnel engaged in forage research in the Northeastern States. It contains reports of research at the U. S. Regional Pasture Research Laboratory and at the State Agricultural Experiment Stations of the 12 Northeastern States. Included are brief and, in some cases, condensed reports of some Regional Technical Committees. Thanks are due to the Collaborators, to the chairmen of the Technical Committees, and to others who collected and edited these reports.

There were changes in personnel at the Pasture Laboratory during the past year. Dr. Clyde C. Berg, with degrees from Kansas State University, Oklahoma State University and Washington State University, joined the staff in April, 1966, to direct the genetic and cytogenetic research on grasses, filling the vacancy left by the transfer of Dr. A. W. Hovin to Beltsville in 1965. Dr. Kenneth T. Leath, with degrees from the University of Rhode Island and the University of Minnesota, joined the staff in August, 1966, to direct the research in plant pathology, filling the vacancy left by the transfer of Dr. J. H. Graham to the Vegetables and Ornamentals Research Branch early in 1966. Carol S. Shores, with an M.S. degree from The Pennsylvania State University was appointed as a research assistant in grass cytogenetics succeeding Dr. Helen D. Hill who retired in 1965. James H. Elgin, Jr., with an M.S. degree from the University of Maryland, was appointed a part-time research assistant in alfalfa genetics.

Dr. D. D. Wolf, Collaborator from the Connecticut Station, resigned as Collaborator early in 1967 and the vacancy has been filled by Dr. W. W. Washko.

A conference of the Collaborators was held at University Park on October 27-28, 1966. On the program were reports of research at the Pasture Laboratory by members of the staff and presentations by the Collaborators of the areas of research where the Laboratory can best serve the needs of the region. Other subjects discussed were a proposed expansion of the Laboratory facilities, a reorganization of the administration of the Laboratory, and the future of this Report. Dr. C. S. Brown was elected chairman of the Collaborators and Dr. G. M. Wood secretary. A summary report of the conference has been distributed to the attendants, about fifty in number.

The Pennsylvania State University has offered the use of land for experimental plots at its new Agricultural Research Center at Rock Springs, a village about nine miles west of the campus. Beginning in the spring of 1967, new plantings will be made at this location. The advantages of this area are that the soil is more fertile and uniform and irrigation water will be available. A disadvantage is that it is a long distance from the Laboratory.

An addition to the equipment of the Laboratory during the year is a Mathatron Desk Computer, which will make possible greater speed and accuracy in many statistical studies.

Late in 1966 the staff of the Laboratory was asked to prepare Design Criteria for the expansion of the Laboratory building. Different members expressed their ideas for expansion by drawing rough plans and indicating the kind of fixed equipment necessary. At the time of this writing, government architects are examining these criteria and will prepare more professional plans. There is a good prospect that the main building will be enlarged by an addition to the rear in the near future.

A committee to revise this Annual Report was appointed, as follows: R. B. Alderfer, G. G. Pohlman, C. C. Lowe, J. S. Starling, H. R. Fortmann, and J. T. Sullivan. This committee will have recommendations in time for any changes to go into effect for the Report of the year 1967.

RESEARCH AT THE PASTURE LABORATORY

ALFALFA

Polycrosses of Disease Resistant Alfalfa Clones

History and development of clones resistant to several foliar pathogens were given in previous reports (see 1965 Annual Report, p. 2). Since suitable epiphytotics of specific pathogens did not develop, the polycross progenies were screened for resistance to Leptosphaerulina briosiana, Pseudopeziza medicaginis, Ascochyta imperfecta, and Uromyces striatus in greenhouse and growth chamber facilities.

Screening Alfalfa for Insect Resistance

A procedure for screening alfalfa for resistance to spittlebug, potato leafhopper, and alfalfa weevil was given in the 1965 Annual Report (p. 2). The first cycle of phenotypic recurrent selection for resistance to these insect pests was completed and the second cycle initiated. Conclusions as to the effectiveness of the selection program cannot be made at the present time.

A sufficient level of weevil damage for scoring developed in a nursery of 407 alfalfa introductions (see 1965 Annual Report, p. 2). Differences in the amount of damage were present, but none of the plants was considered really outstanding.

Comparison of Different Cycles of Phenotypic Selection in MSA and MSB Alfalfa

First harvest yield and several other agronomic traits were measured in a study to determine the extent of genetic shifts that may have occurred in four phenotypic recurrent selection programs (see 1965 Annual Report, p. 3). A detailed analysis of the data has not been made, but preliminary analyses indicate that a higher selection pressure for a given character results in greater shifts in other characters.

Bacterial Wilt and Crown Rot Resistant Selections of Alfalfa

History of the Connecticut clones and experiments in progress were given in previous reports (see 1965 Annual Report, p. 3). Survival notes were made on a 1962 planting near State College, Pa. (14 plants per row); progenies of the Connecticut clones averaged 6.8 plants per row, DuPuits - all dead, Narragansett - 3.0, and Vernal - 4.0. Single crosses between 9 clones selected from this nursery and between 10 clones selected from wilt-resistant DuPuits nursery have been made in the first step of production of 4-clone synthetics within each group.

Comparison of 4 Methods of Selection in Alfalfa

The first 2 cycles of selection in a program to compare the relative effectiveness of tandem, independent culling levels, sums of ranks, and index methods of selection for resistance to 4 alfalfa pathogens (Uromyces striatus, Pseudopeziza medicaginis, Ascochyta imperfecta, and Leptosphaerulina briosiana) and for recovery after cutting have been completed. Original plans included Corynebacterium insidiosum instead of A. imperfecta in the selection program, but the petiole method of inoculation with C. insidiosum was not very reliable.

Inbreeding in Alfalfa

History and developments of the inbreeding study are given in previous reports (see 1965 Annual Report, p. 4). Thirty-six lines of Pool A and 32 of Pool B produced S₃ seed, and the majority of the S₃ plants are setting S₄ seed.

Relationships of Sitona hispidula and Incidence of Disease Caused by Fusarium oxysporum medicaginis and by Corynebacterium insidiosum

Ten replications of S. hispidula, F. oxysporum medicaginis, and C. insidiosum were placed in factorial combinations in 6-inch clay pots seeded with 10 plants of DuPuits alfalfa. Sitona larvae did significant damage to the roots, and the presence of Sitona appeared to increase the incidence of Fusarium wilt. Wilt caused by C. insidiosum did not develop in any of the pots, possibly because the strain was avirulent.

Effect of Foliar Diseases on Coumestrol Content

In cooperation with personnel from the Western Utilization Research and Development Division, the Crops Research Division, ARS, USDA, and the South Dakota Agricultural Experiment Station, it was demonstrated that infection of alfalfa by Pseudopeziza medicaginis, the common-leafspot organism, caused an increase in flavones and coumestans which was positively correlated with host susceptibility. Studies of alfalfa infected with rust (Uromyces striatus) gave similar results. Selection of alfalfa for resistance to common leafspot and rust can be expected to reduce the high levels of coumestrol induced by these diseases.

Aseptic Growth of Plants

Aseptic plant culture has many applications in plant pathology, especially in root disease research. New techniques for seed sterilization and chamber sanitation are being used in current growth trials. The longest period during which plants have been grown aseptically in flexible-film isolators has been 5 months.

Myrothecium Leafspot

Ecological, physiological, and pathological investigations with Myrothecium spp., which cause leafspots on alfalfa, clover, and other legumes, are being continued. A phytotoxic substance produced by the fungus is being examined chromatographically and spectrophotometrically to define its chemical and physical properties.

Sporulation of Pseudopeziza medicaginis

Trapping of ascospores of P. medicaginis during an inoculation in the growth chambers indicated that a peak in spore discharge occurred within 4 hr after cultures were moved from 5°C to 20°C, and that twice as many spores were discharged during the first 4 days than during the second 4 days. A great difference was noted in the physiologic age of apothecia, of the same calendar age, as measured by the time required for spore discharge.

RED CLOVER

Field Assay for Thielaviopsis basicola

T. basicola, found to be causing cortical rot of Pennscott red clover in the greenhouse, was not detected in soil samples from three field locations around State College, Pa. No effects of soil mixtures or daylength on the pathogenicity of this fungus were observed in other studies.

Role of the Clover Root Borer as a Virus Vector

The clover root borer, Hylastinus obscuris, often associated with the occurrence of virus in the field, is being investigated as a possible vector. No conclusion can be made at this time.

Persistence Studies in the Field

During the second harvest year, selections of red clover were compared with control plants of unselected Pennscott on a basis of ground cover. Selections for resistance to internal breakdown did not persist as well as Pennscott; the 1959 general persistence selections appeared slightly better than Pennscott. Unfavorable climatic, edaphic, and parasitic factors during this trial afforded a severe test of the plants' persistence ability.

An experiment to determine effects of insects and soil microorganisms on persistence was initiated in 1964 and outlined in the 1965 Annual Report. The polycide-drench treatment was discontinued at the end of the 1965 season, since no effect was evident. In the second harvest year (1966), plants in caged and noncaged plots receiving insecticide drench again yielded almost twice as much as untreated control plants, although yields were 14-39% lower than in 1965. The highest rate of winter survival occurred in insecticide-treated plots, and the incidence of virus diseases (principally red clover vein mosaic) was 24-30% in noncaged plots and 2% in caged plots. Borer damage was frequently found in roots of dead plants in control plots but only rarely in roots of dead plants in insecticide-treated plots.

Internal Breakdown

Since phenols have been associated with internal breakdown (IB) in red clover, attempts were made to induce symptoms of IB with selected phenolic substances applied topically to clover crown tissue. All test compounds produced some discoloration, but only that induced with gallic acid simulated the appearance of tissue with IB.

Histological and cytological observations of IB tissues indicated that red clover crowns often had incipient IB that was not detected by macroscopic examination. Accompanying IB development was a deficiency or complete absence of starch. This lack of starch reserves may be an important factor in the lack of persistence of red clover.

The effect of clover and other plant debris on the incidence and severity of IB was investigated, since such a relationship has been demonstrated for corky root rot of lettuce, also a physiogenic disease. After 7 months no effect of the debris amendments on the development of IB was observed.

The effect of photoperiod on growth habit and development of IB was studied with early, intermediate, and late-flowering red clover introductions from England. Plants grown under a 16-hr photoperiod had smaller crowns and fewer tillers than plants grown under a natural day length of 10-13 hr. Dry matter yields under long-day conditions were higher after 5 months than yields under short-day conditions, but subsequent dry matter yields over a 2-month period were greater under the shorter photoperiod. The incidence of IB was slightly higher in plants grown under long-day conditions. The size of IB was not correlated with day length or incidence of IB. Incidence and severity of IB were greatest in the variety Pennscott, and IB tended to develop earlier in intermediate and late-flowering English varieties.

BROMEGRASS

Selections with Leaf Disease Resistance

Both Syn 1 and Syn 2 seed were harvested from isolated field plantings of the 6-clone Syn D and the 7-clone Syn E brome grass synthetics. The amount of Syn 1 seed produced and the germination percentages were quite variable. Drought limited the progeny test to one harvest. This year, in contrast to 1965, Saratoga was among the lowest entries in the test.

ORCHARDGRASS

Nonheading Orchardgrass

(In cooperation with G. M. Wood, University of Vermont)

The Syn 1 generation of three 4-clone synthetics was evaluated at University Park, and in Vermont in solid-seeded field plots established in 1964. The heading responses were very similar at the two locations. Pennlate, Syn A, Syn B and Syn C produced respectively: 30.8, 21.1, 11.3 and 6.1 panicles per square foot in Pennsylvania and 27.8, 20.1, 12.5 and 8.0 in Vermont. The production of dry matter was nearly equal for all four entries, except that Syn C produced significantly less dry matter in Vermont. In Pennsylvania, Pennlate yielded the most dry matter while Syn B was the lowest.

Male-Sterile Orchardgrass

About 3000 orchardgrass plants constituting 6 F₂ populations were examined for male sterility. The progeny of one cross, represented by 247 plants, included 5 male-sterile plants, while the other crosses resulted in 0 to 2 male-sterile plants. The low frequency of male-sterile plants may mean that cytoplasmic factors are involved in the expression of male sterility. On the other hand, since some male-sterile plants were observed, it is possible that the genotype (or genotypes) necessary for the expression of male-sterility in tetraploid orchardgrass was recovered infrequently in these populations.

RYEGRASS-FESCUE INTERGENERIC HYBRIDS

Syn 1 seed was harvested from 8 different 4-clone trispecies Lolium-Festuca hybrids grown under muslin covered cages. The quantity of seed produced by each clone was variable, with some clones failing to produce seed while others produced over 60 grams clean seed. At least part of this difference was caused by differences in the number of heads produced by individual plants. Although temperature and humidity were high in the cages, the lowest germination of any clone was 82%, and most were above 90%. Syn 2 seed was harvested from isolated plantings of Syn 1 plants. The chromosome number of progeny of several ryegrass-fescue clones (2n = 28) X tall fescue crosses have been determined. A number of them have 28 chromosomes, while others were found to have 35 or 42 chromosomes. These plants will be backcrossed to tall fescue and intercrossed.

A number of samples of hybrids harvested in 1964 were analyzed and were found to have in general, a low lignin content and a high in vitro dry matter digestibility.

MISCELLANEOUS

Carbohydrate Studies on Forages

Further carbohydrate analyses were made of 83 samples of forage representing 7 species; the samples were furnished by the West Virginia Station and are of known digestibility of dry matter (DDM) and relative intake (RI) (see 1965 Annual Report, p. 8). The percent hemicellulose was negatively correlated with DDM; it was also negatively correlated with RI but in some species the coefficients were not significant. The digestion coefficient of hemicellulose was positively correlated with DDM; it was positively correlated with RI but in some species the coefficients were not significant. The hemicellulose:cellulose ratio was positively correlated with DDM in most species but few coefficients were significant; there was no consistency in the relation between this ratio and RI. No constituent so far studied has been found to be correlated with relative voluntary intake except those which are also correlated with digestibility.

The Dry Matter Content of Forage Plants

The percent dry matter (%DM), more explicitly the dry matter in percent of green weight, of forage at the time of harvest has been reported by others to be negatively correlated with dry matter digestibility (DDM). A limited study of %DM in several grasses, alfalfa, and red clover was made during the early part of 1966 and with first cuttings only. Leaves were found to be higher in %DM than stems or whole tops; as leaves are considered higher in DDM than stems the results do not point to the expected relationship. The %DM was lower in legumes than in grasses. The higher %DM in leaves as compared with stems and in legumes as compared with grasses may be associated with a higher proportion of soluble substances in each case and soluble substances are usually very digestible; these results again do not point to the expected relationship. The %DM was different in the afternoon from that of the forenoon but the relationship was not consistent; it seems unlikely that the DDM would change over a period of a few hours in the same degree as the %DM changed. There was no continual increase in %DM to accompany what is known to be a continual decrease in DDM with advance of maturity but the scope of the experiment was insufficient for definite conclusions. While these results are not conclusive, they do not seem to establish that a close negative relationship exists between %DM and DDM under every condition. The experimental conditions during 1966 were not ideal for this study.

Plant Competition Studies

Ladino clover was grown alone in nutrient cultures and also was transplanted into established orchardgrass (see 1965 Annual Report, p. 13). The cultures were of two concentrations. Some nutrient solutions were changed frequently and others were not changed during the experiment to allow an accumulation of any substances released by the plant roots. The solutions that were not changed received measured quantities of 1.0 N HNO_3 and 0.5 N KNO_3 to control pH and to maintain N and K levels. Techniques were used to provide equal light to clover whether grown alone or in association with orchardgrass.

Growth of both tops and roots of ladino clover was as good in association with orchardgrass as in monoculture. There was no evidence that roots of vigorous, well established orchardgrass plants released substances in the nutrient solution that inhibited growth of ladino clover.

Climate at State College, Pa.

The total precipitation in 1966 was 30.63 inches, 8.07 inches below the 1930-1960 mean, and with very dry spells in late spring and summer. In spite of this, surface moisture was present on leaves at 8:00 AM on 250 days of the year, on 56 days as snow, 80 as rain, 74 as dew and 40 as frost. Soil moisture was limited during the summer, the wilting point (10% or less) being reached as far down as 16 inches below a bluegrass sod.

The mean daily temperature for the year was 49° , 1° below the normal while January was 6° below normal and July 2.4° above. The daily range of temperature was greatest near the ground level; in June the daily range was 10.4° greater at 3 inches above ground than at 60 inches while in December with intermittent snow it was only 0.8° greater at 3 inches than at 60 inches. Without snow however the daily range in winter was 3 to 5° greater at 3 inches than at 60 inches. Yearly mean soil temperatures were about the same at all depths up to 20 inches, about 52° , but the mean daily range was greater at a shallow depth (10.6° at 2 inches) than at deeper ones (0.8° at 20 inches).

Relation of Soil Temperature to Responses to Fertilizers

Red clover seedlings were grown in controlled temperature chambers at 20 or 21°C air temperature and 10° and 20 or 21°C soil temperature (see 1965 Annual Report, p. 12). Responses to P and K fertilization were determined after equal growth periods and for comparable stages of plant development.

Growth was far greater at a soil temperature of 20° than at 10°. Moreover the responses to P fertilization increased progressively with time. This was true also of the response to K, except that the effects of length of the growth period were much less striking.

Responses to P for comparable stages of plant development, however, were in rather good agreement for the two soil temperatures. The trend was for somewhat greater responses at the lower temperature, but this trend was small in comparison with the marked responses to P at both soil temperatures.

Responses to K were much smaller than the responses to P, but for comparable stages of plant development they were greater at low soil temperatures than at a more nearly optimum soil temperature.

Competition for Potassium by Grass-Legume Associations

Third harvest year dry matter production and percentage alfalfa in the forage were obtained for a field plot trial to study the competition for K between alfalfa and orchardgrass seeded in 7-inch alternate rows and in mixed rows using different rates and placements of K fertilizer (see 1965 Annual Report, p. 13).

Forage production was again curtailed by insufficient rainfall, particularly during the latter part of the growing season, and K fertilizer gave little increase in yield of either alfalfa or orchardgrass. Alfalfa has persisted somewhat better when the alfalfa and the grass were seeded in alternate rows than when mixed in the same row.

Potassium content of the alfalfa and the grass indicates that seeding in alternate rows reduced the competition for K. Both species, particularly the legume, were higher in K when grown in alternate rows than when they were grown together in the same row. Orchardgrass generally was about twice as high in K as was the associated alfalfa, emphasizing the need for reducing the competition for K between these species.

REPORTS OF NORTHEAST REGIONAL RESEARCH

Title: PROJECT NE-9 - THE INTRODUCTION, TESTING, MULTIPLICATION, AND PRESERVATION OF POTENTIALLY VALUABLE PLANTS FOR CROP IMPROVEMENT AND INDUSTRIAL USE

Leaders: D. D. Dolan, Project Leader; S. W. Braverman, W. R. Sherring, and W. W. Steiner, Chairman, Regional Technical Committee

Cooperators: Fourteen State Agricultural Experiment Stations of the 12 Northeastern States, the New Crops Research Branch, ARS; the Soil Conservation Service, and the Cooperative State Research Service, USDA

The plantings at the New York State Agricultural Experiment Station at Geneva consisted of over 990 forage legumes and grasses, of which 600 were carried over from 1965. Descriptive and evaluation notes were recorded and the information was distributed to plant breeders in the annual catalog. Some exceptional introductions are mentioned, as follows:

An alfalfa introduction (P.I. 237723) from Germany was vigorous and productive but not winterhardy. A selection from it (P.I. 237723-S) has proved to be winterhardy, vigorous, productive, leafy, and, at several locations, tolerant to powdery mildew. A Polish introduction (P.I. 274639) is winterhardy, vigorous, and productive. Two French introductions (P.I. 236605 and 256004) show potential and adaptability; the former is vigorous, leafy, erect, and productive; and fairly hardy; the latter is very hardy and has the same good qualities as the other.

A birdsfoot trefoil from Argentina (P.I. 161878) is outstanding for winter-hardiness, spring recovery, persistence, vigor, and leafiness in the northern latitudes.

An orchardgrass from the Netherlands (P.I. 237176) is winterhardy, resists lodging, has vigor, leafiness, good recovery after cutting, and good fall growth.

A timothy selection (P.I. 285540) is resistant to stem and leaf rusts, is winterhardy, spreading, vigorous, leafy, and productive. A timothy from Poland (P.I. 274643) has similar qualities. Another timothy (P.I. 237191) is considered excellent; it is winterhardy, leafy, and late blooming.

Domestic exploration yielded an outstanding smooth brome grass from New Hampshire (P.I. 231758). Another brome grass from USSR (P.I. 251682) made good spring recovery and had less brown spot.

A tall fescue from the Netherlands (P.I. 265359) is hardy, erect, vigorous, leafy, and productive. One from South Africa (P.I. 195477) has tolerance to both heat and cold.

Two winterhardy ryegrasses were found, one (P.I. 265335) from Sweden and one (P.I. 265344) from Ireland.

Supplements to the main report list many other introductions. Supplement I describes red clover, white clover, and miscellaneous clover and Lotus species and 12 grass species. Supplement II reports on leaf and stem rust resistance in timothy, crown rust on tall oatgrass, blackstem resistance in alfalfa, and seed inhabiting fungi on both legumes and grasses.

Title: PROJECT NE-13 - MECHANICAL AND PHYSICAL PROPERTIES OF FORAGE RELATED TO PROCESSING, PRESERVATION, AND UTILIZATION

Leader: R. P. Prince, Chairman, Regional Technical Committee

Cooperators: The Agricultural Experiment Stations of the 12 Northeastern States and the Cooperative State Research Service, ARS

Research during the year was conducted under the old and under the revised project. For the title of the old project, which expired June 30, 1966, see the 1965 Annual Report, p. 16.

The modulus of elasticity of alfalfa showed only small variation between varieties and was relatively constant throughout the length of each stalk.

The laboratory forage dryer and associated instrumentation were modified and calibrated to permit continuous recording of temperature and sample weight throughout the drying cycle. A computer sub-program was written to convert the nonlinear infrared thermometer output as recorded to temperature in degrees F.

Laboratory tests were made on silage to determine the relationship between compressive stress, density, and stress required to produce failure in simple tension. Results indicated that for densities normally encountered in the silo, stress at failure in simple tension and compressive stress were exponentially proportional to the density. Stress at failure was directly proportional to the compressive stress indicating that the resistance in tension was directly related to coulomb friction. Quantitative relationships between density, compressive stress, and failure in tension will be determined.

Analysis of drying rate data showed low relative performance for hay pellets as compared to baled hay and indicated that whatever drying is required should precede the pellet formation. Results of the baled hay drying experiments showed that drying efficiency using air temperatures

of 120°F was decreased when compared with either 90°F or 150°F.

Alterations to an experimental wafering machine were made. The loading chamber gate pneumatic operating system was rebuilt using different air cylinders which enlarged the throat opening resulting in an increase in the wafering rate.

The new project, begun July 1, 1966, has the title given at the beginning of this report.

Results of limited testing to determine the shear stress of the outer shell of corn stalks indicated that shear stress was not influenced by stalk moisture content. Shear stress of the outer shell of stalk from the base to above the ear remained relatively constant over the entire range of moisture contents.

A mathematical model was used to describe the drying of an element of forage when heat was transferred by convection and radiation. Results indicate that a coefficient of radiation and a coefficient of convective heat transfer may be calculated from elemental drying tests conducted.

The effects of water vapor release on the transport velocity of the drying gases (air) are being studied by two methods. The first method involves the direct release of moisture into a vertical hot air stream; the second involves a product in a three-stage fluidization drying process. Instrumentation for the study of both methods has been completed. Velocity divergence studies are basic to the design of the process stages.

Modifications were made to the 16-ft and to one of the 14-ft diameter self-feeding silos. Additional material support was provided in the 16-ft silo by increasing the penetration of the wheels and baffles by two inches. A moment of about 160,000 inch-pounds was recorded for each wheel with the silo filled with direct-cut corn silage. Sixteen sets of 4 baffles each were installed in the 14-ft silo. Results show that the adjustable lower pair supported an average load of about one and one-half tons vertically and an equivalent load horizontally. Alterations were made to the feeding gates in the self-feeding hay barn to reduce feed wastage.

A chopping device for laboratory use was examined to determine its performance in reducing forage plants into uniform particles of predetermined length. Following several machine modifications results showed stem particle measurements of forage and corn to be in a narrow distribution about the selected length. A hydraulic press to determine the mechanical properties of reduced forage samples was constructed, instrumented and tested.

Twenty-five percent glass-filled teflon hay wafering dies required one-third to one-half as much pressure to form wafers as steel dies. Results of wafering tests show no difference in the work done per pound of hay with a charge rate of up to three-quarter pound. A one-pound charge rate

increased the work per pound of hay 11%. The reducing diameter extrusion process produces an accordion pleated wafer of high durability. Durability of year-old chopped hay wafers remained high, dropping only from 87 to 83%.

Drying facilities were modified to accommodate sufficient capacity for feeding trials. Results of drying wilted baled forage showed insufficient drying in the center of the bale. Four common fungi were present in the bales tested: two of the genus *Rhizopus*, one *Aspergillus* and one *Penicillium*.

USEFULNESS OF FINDINGS:

Results of forage drying tests are expected to serve as a basis for a mathematical expression appropriate for predicting drying rate of forage exposed to high temperatures and infrared radiation. The fluidization drying process will provide design information for dehydration of forage on the farm, thereby reducing field losses and maintaining high levels of protein.

Data on the behavior of forage in mass flow and on the forces required to control the mass will be used to design more reliable self-feeding structures.

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

Leader: Guy W. McKee, Chairman, Regional Technical Committee

Cooperators: The Maine, Maryland, Massachusetts, New Jersey, New York (Geneva and Ithaca), Pennsylvania, and Rhode Island Agricultural Experiment Stations, the Forage and Range Research Branch, the Biological Science Branch, the Seed Branch, ARS, and the Cooperative State Research Service, USDA

In New York a study was made of the effect of light quality and length of photoperiod on 11 varieties of Kentucky bluegrass. Differential varietal responses were found in tillering, rhizome development, and anthocyanin pigmentation at the base of the plants.

In several grass species the percentage of plants with anthocyanin pigmentation at the base of the plant has been useful in varietal purity determinations. Studies were conducted to determine what conditions favor anthocyanin development and under what conditions varietal differences are greatest. The use of incandescent bulbs to supplement light from

fluorescent tubes greatly reduced anthocyanin pigmentation of perennial ryegrass varieties. This light treatment also reduced anthocyanin in orchardgrass varieties but did not reduce pigmentation of Kentucky bluegrass varieties.

Eleven varieties of orchardgrass and 6 varieties of timothy were grown under a series of environmental conditions. Useful varietal differences in growth habit were found for orchardgrass. Timothy varieties differed in tiller production and leaf width.

Two growth chambers were equipped to grow plants in sand, automatically watered with nutrient solutions. With some nutrient and environmental combinations more than 90% of the plants of alfalfa and early birdsfoot trefoil varieties were induced to bloom within 5 weeks of the time they were planted. Annual ryegrass plants could be distinguished from perennial plants within 4 weeks on the basis of heading, development of seed stalks, or leaf bud shape.

Maleic hydrazide applications to soil in which Kentucky bluegrass seedlings were growing revealed useful varietal differences. Prato and Atlas retained green foliage color. Other varieties lost their green color and turned brown.

In Pennsylvania work was continued on the use of instrumental techniques to evaluate varietal differences in flower and leaf color of alfalfa, birdsfoot trefoil, and red clover. Several types of color measuring devices, colorimeters, spectrophotometers, and color difference meters were evaluated. Presently a color coding device, using a filter wheel with eight different narrow band pass filters, is being evaluated. Neither seed lot (13 lots Ranger) nor geographic origin (2 seed lots each of 10 varieties) had significant effect on flower and leaf color of plants grown and measured under standardized conditions compared to differences found between ten varieties of alfalfa. Thus, this technique is of value in varietal purity testing in alfalfa. Work is continuing on varietal differences in flower and leaf color of several other leguminous species. To make use of this technique, feasible methods of accelerating blooming were further investigated. Under continuous light, fluorescent plus incandescent, and rather warm plant temperatures (95°-100°F) plants of red clover, alfalfa, birdsfoot trefoil, alsike clover, and sweet clover bloomed 3 to 4 weeks after seeding.

Studies were also continued on serological differences in several varieties, strains, and seed sources of crownvetch. Significant varietal differences were found using the ring test and Ouchterlony double diffusion. Seed of the variety Penngift has a protein content significantly less than seed of Chemung and Emerald. This work, plus related work in West Virginia with alfalfa and field beans, suggests that the serological approach to varietal purity testing has considerable merit. Presently, all possible cross reactions are being run for antigen and antisera of several seed lots of each of the three released varieties of crownvetch.

In a different approach to varietal purity testing, significant varietal differences in rate of apparent net photosynthesis were found for seedlings

of seven crop species. All plants were grown and tested under standardized conditions.

The use of four stress tests to evaluate seed vigor in reed canarygrass was studied. Results were compared with field emergence, seedling establishment, and the standard germination test. A combination of hot flood test (seed immersed in water for 5 days at 95°F) plus the standard germination test was useful in predicting field performance in 1965.

USEFULNESS OF FINDINGS:

Methods of varietal purity testing developed and evaluated under this project are of value in checking compliance with seed laws and regulations and in assuring the purchaser that his seed is correctly identified as to variety. Techniques presently available permit determination of varietal purity in certain species in a matter of weeks rather than months as was formerly the case. At times gross varietal misidentification of a given seed lot can be detected with one test. In general, however, a battery of two or more different varietal purity tests, applied either consecutively or sequentially, are required. There is need, therefore, to develop techniques to utilize many diverse plant characteristics in varietal purity testing.

Work carried out in New York will aid in selecting environmental conditions to accurately bring out varietal differences in timothy, orchardgrass, and Kentucky bluegrass. Treatment with various chemicals differentiate off-type plants in certain varieties of Kentucky bluegrass.

Work carried out at Pennsylvania suggests the use in varietal purity of testing instrumental measurements of plant characteristics of plants grown and measured under standardized conditions. In addition, serological and chromatographic techniques offer a possibility of varietal purity tests that can be conducted in a few hours or a few days.

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

Leader: N. F. Colovos, Chairman, Regional Technical Committee

Cooperators: The Agricultural Experiment Stations of the 12 Northeastern States, the U. S. Regional Pasture Research Laboratory, the Dairy Cattle Research Branch, ARS, and the Cooperative State Research Service, USDA

The objectives of this regional project are: (1) to evaluate forages of various species and varieties grown under known conditions and harvested at specific dates and stages of maturity by determining the digestibility of energy and protein and the daily consumption rate; in fewer instances,

forages will be evaluated in terms of animal production responses and energy balances, and (2) to determine the fundamental conditions controlling the amount of forages ingested by ruminants and to develop methods for measuring and predicting the daily forage consumption rate.

The nutritive value of forages, as measured by daily rate of consumption and digestibility, was continued during the past year by many of the stations. Factors studied were: (1) cutting date and growth stage (Maine, Maryland, New Hampshire, New Jersey, Pennsylvania, Rhode Island, Vermont, West Virginia, Dairy Cattle Research Branch); (2) forage varieties within a species (New York, Pennsylvania, West Virginia, Dairy Cattle Research Branch); (3) effect of regrowth interval on aftermath growth (New Hampshire, New Jersey, Vermont, Dairy Cattle Research Branch); (4) nitrogen fertilization (Rhode Island, Massachusetts, Pennsylvania, West Virginia); (5) phosphorus fertilization (Maine); (6) method of storage (New Hampshire, Maryland, Massachusetts, New York); (7) trace element fertilization (West Virginia); and (8) level of intake (Maine, New Hampshire, Vermont, Rhode Island, New York, Maryland, Pennsylvania, New Jersey, Dairy Cattle Research Branch, Delaware).

Additional data this past year emphasize the importance of early harvesting to obtain the greatest nutritive value (Maine, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia, Dairy Cattle Research Branch). Net energy, as measured by stored energy with the comparative slaughter technique, decreased with advancing maturity of orchardgrass and was associated with increased lignin content (New Jersey). The same relationship of effect of stage of maturity was established with reedtop and reed canarygrasses in net energy studies using indirect calorimetric techniques (New Hampshire).

Early clipping delayed the maturity of timothy but did not affect dry matter digestibility (DDM). Varying levels of phosphorus fertilization affected the P content of timothy, but did not affect DDM or acceptability. Supplemental feeding of NaH_2PO_4 with "low-P" forage did not alter its DDM (Maine).

Second cutting reed canarygrass grown under four levels of nitrogen fertilization showed an increase of the DDM and digestible crude protein and a decrease of fiber and NFE with the increase of nitrogen. Volatile components in grass and legume silages were tested and it was found that silages with offensive odor contain considerable amounts of higher VFA, such as n-valeric, n-caproic, isobutyric and isovaleric (Massachusetts).

The net energy of reed canarygrass, determined by means of an open-circuit indirect calorimeter and from the heat production at two levels of nutrition, was a more sensitive method of comparison of the nutritive value of the different hays than either TDN or digestible energy. The net energy of the reed canarygrass preserved as haylage was lower than the comparable harvest preserved as artificially dried hay (New Hampshire).

The effects of undigestible fibers and particle size on voluntary consumption of hay by sheep were studied by introduction of polypropylene fibers.

Introduction of 30 cm lengths of these fibers into the rumen of wethers reduced intake and increased digestibility. When time of access to hay was limited, a further decrease in intake occurred. Addition of pelleted alfalfa resulted in increased total dry matter intakes by polypropylene treated wethers (New Jersey). The distribution of lignin among fecal cell-wall particles indicates a much greater lignin content in fine particles than in larger ones. These findings have important implications in regard to the effects of fill and rate of passage on voluntary intake (Dairy Cattle Research Branch).

Based on observations of some 25 forages fed simultaneously to wethers and steers, body weight to the power of 0.84 continues to be the best-fit parameter equating the intake of the two animal species, i.e., the coefficient of variation between the measured and estimated intake is minimal (ca. 11%) (New York).

Four annual forages, Piper sudangrass, Trudan 1 sudangrass hybrid, Sweet Sioux, and grazer sorghum-sudangrass hybrids compared favorably in nutritive value and acceptability to those of perennial forages. The annual forages were surprisingly high in mineral content (Pennsylvania).

Fertilization with a trace mineral mixture gave increased DDM on first cuttings. Liming gave a consistent increase in intake, but did not affect DDM. Four levels of nitrogen, 0, 50, 150 and 450 lb fertilization increased the estimated DDM as the level of nitrogen increased (using "local regression") when the forage was grazed May, June, September and March. However, the nitrogen increase had little effect on intake except in the May and March trials (West Virginia).

In the continuing efforts to relate chemical composition of a forage to its nutritive value and working with forages of known digestibility and intake the results so far show that no constituent seems to be correlated with intake except those which are also correlated with digestibility.

Experiments are in progress to use water content as a predictor of digestibility for screening plant populations (U. S. Regional Pasture Research Laboratory).

In vivo and in vitro data indicated that silicification has an important effect in depressing digestibility of forages. This effect is additive with respect to lignification of the cell wall. The study also indicates that there are other unknown factors that affect digestibility (Dairy Cattle Research Branch, ARS).

Nutritive value of three varieties of orchardgrass was studied using sheep and rabbits. Energy, protein and dry matter digestion coefficients in rabbits were significantly correlated with corresponding values in sheep, although there was no such relationship with respect to voluntary intake (Delaware).

USEFULNESS OF FINDINGS:

Data accumulated on the relationships of cutting date and maturity to the yield and nutritive value of forages will serve as the basis for recommending feeding and management practices. Prediction equations of nutritive value based on chemical composition are being developed.

Agronomists are being aided in the development of new forage varieties by giving them methods by which they can obtain an early prediction of the nutritive value of the forages.

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

Leader: R. R. Seaney, Chairman, Regional Technical Committee

Cooperators: The Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and West Virginia Agricultural Experiment Stations, The U. S. Regional Pasture Research Laboratory, The Forage and Range Research Branch, ARS, the Cooperative State Research Service, USDA, and the American Seed Trade Association.

Regional evaluation of experimental varieties.--Breeding and evaluation studies involving six forage species were continued in eight Northeastern states and at the U. S. Regional Pasture Research Laboratory. Seed production of experimental materials for investigations on variety synthesis in perennial forages was continued in three states; four states are cooperating in evaluation phases. In alfalfa, experimental synthetics carrying the creeping-rooted-gene with acceptable levels of background vigor have not yet evidenced any spreading after 2 years of broadcast plot competition. Saranac and Iroquois, most recently released Northeast varieties, are showing outstanding performance. Synthetics of trefoil, timothy, and orchardgrass are being regionally evaluated. None are scheduled for early release.

Orchardgrass.--At New York and Pennsylvania, forage yields were obtained for polycross progenies of 66 clones. Three years of evaluation have indicated that several progenies are higher yielding than check varieties. Parent clones of these progenies will be combined into experimental varieties.

Several experimental synthetics (Syn 1 of 4 clones) of nonheading orchardgrass have been developed by the U. S. Regional Pasture Research Laboratory and Vermont. First year evaluation of three synthetics indicates that one synthetic (Syn C) produces only a few panicles and is similar to

Pennlate in forage yield. Isolation plots were established at Prosser, Washington for the production of Syn 2 seed of the three synthetics.

Bromegrass.--Two synthetics have been produced from parent clones resistant to Helminthosporium bromi, Stagonospora bromi, and Rhynchosporium secalis. Parent clones were selected on the bases of progeny tests conducted at the U. S. Regional Pasture Research Laboratory and New Hampshire. Syn 1 and Syn 2 seed of the synthetics (D and E) were produced in isolation plots at University Park, Pennsylvania.

Alfalfa.--Polycross progenies of 65 clones with Vernal germplasm were evaluated for resistance to Pseudopeziza medicaginis, Ascochyta imperfecta, Uromyces striatus, and Leptosphaerulina briosiana. These clones were previously evaluated for forage and seed yields in Pennsylvania, Minnesota and Utah. Decisions on the use of superior clones will be made after complete analysis and interpretation of data concerning seed set, yield, and disease resistance.

Variety synthesis studies.--Investigations of synthesis procedures are in progress for six species: alfalfa, birdsfoot trefoil, timothy, bromegrass, orchardgrass, and ryegrass-fescue hybrids. Experimental materials of alfalfa, trefoil, timothy, bromegrass, and orchardgrass are being evaluated in broadcast seeded field plots. Seed of experimental materials is being produced in cage or field isolations in New York, New Hampshire and Pennsylvania. Accomplishments in the production and evaluation phases are outlined below:

Seed production.--Development of production techniques for obtaining adequate amounts of seed of experimental combinations by means of cage isolation has been one of the most significant accomplishments of this project. Adequate seed for extensive evaluation has previously been a serious limitation to forage breeding and to synthesis investigations. In the Northeast, seed production under cage isolation is now satisfactory to highly successful for all species except smooth bromegrass. Studies of cage techniques show that several variables influence both the amount and genetic makeup of the seed produced. Factors of importance are: cage environment (temperature, light, humidity), growth habit and fertility relationships of parent clones, planting arrangements, control of insects and plant diseases, and manipulation of pollinators (honey bees).

Genetic mutants are being isolated for use as markers in synthesis studies. In trefoil, seed stocks carrying the gene controlling production of prussic acid are now being used to identify the hybrid and sib fractions of plant populations in field plots. In alfalfa, the mutant characters "red-root" and "multi-foliolate" have been isolated for use as markers. In bromegrass, color and foliage mutants are being developed by selfing and intercrossing.

Evaluation of synthesis procedures - Alfalfa.--Investigations have indicated stabilized synthetics are equal or superior to doublecross combinations from the same parent clones. Permutations of specific doublecrosses varied in performance; seed generation of parent single cross

lines had little influence on cross performance. Results indicate obligate 2-clone hybrids between high combining clones would have little or no yield advantage over wider-based synthetics originating from the same parent source, using current methods of alfalfa culture.

Timothy.--Crosses between advanced generations of single-clone derived lines are being compared with the clonal cross of the originating parents. With later maturity clones, about a 2-day shift toward earliness has occurred during development of the single clone derived lines. This is expressed in the line x line crosses.

Orchardgrass.--Eleven synthetics formulated either for the region or for specific states within the region are being evaluated in both the first and second generations of seed increase. First year results indicate that the performance of synthetics generally declined when first generation progeny is compared to second generation. The degree of yield decline was not related to the number of parental clones in the synthetics. Some superiority of several synthetics over check varieties is suggested.

Bromegrass.--In a previous test, the Syn 1 generation of 15 diallel single crosses were significantly higher in forage yield than the Syn 2. Similar results were obtained in 1965. In 1966 a second trial involving these crosses, showed the Syn 1 yielding about 11% more than Syn 2. Syn 1 and Syn 2 generations of three, four, five, and six clone synthetics were seeded in plots in 1965. Establishment in terms of plants per square foot was quite variable. In 1966, there were no significant differences in yields between synthetics or generations.

Approximately 300 to 400 F₂ plants from the cross "albino" x normal were selfed. Thirty to forty F₂ plants produced sufficient seed for F₃ segregation data. Segregation ratios in F₂ and F₃ indicate possible tetraploid inheritance for this trait, but this has not yet been demonstrated conclusively.

Trefoil.--Studies of methods of combining clones have shown that different proportions of cross, self, and/or sib seed occur in specific crosses. The influence of the self and sib progeny on total forage yield will probably be negligible since results this year indicate self and sib plants are eliminated from broadcast field plots by establishment competition. Self seedlings were found to be less vigorous than cross seedlings in terms of dry weight yields and survival as spaced plants.

USEFULNESS OF FINDINGS:

The release of several forage varieties by state experiment stations of the Northeastern region has been facilitated by performance information gathered from NE-28 experiments over several years. Varieties recently released are: (1) Alfalfa - Iroquois, Saranac, and Mark II. (2) Orchardgrass - Pennmead.

Trials of polycross progenies and synthetics are a valuable source of information concerning forage productivity, quality, disease resistance, tolerance to different managements, and stand longevity. The assessment of characteristics of experimental forages, along with information about geoclimatic-genotypic interactions, is essential to the formulation of superior varieties with wide adaptation in the Northeast. For most species, experimental varieties being studied in current trial series represent the culmination of twenty or more years of breeding research.

Information collected on studies of variety synthesis procedures has been useful in determining the efficiency of current breeding methods, and in suggesting alternative new methods to be tried. Studies in alfalfa indicate that development of wide-based stabilized synthetics derived from superior clones is an efficient means for obtaining superior varieties to be used under current methods of culture.

Techniques developed for producing multiple increases of forage crop seed in the Northeast have made possible the production of seed in amounts adequate for extensive evaluation studies.

Study of genetic mutants has developed tools for use in studying synthesis procedures. The work with birdsfoot trefoil has provided an example of how to use plant mutant characters in breeding methodology studies.

Title: PROJECT NE-29 - MORPHOLOGICAL AND PHYSIOLOGICAL RESPONSES
OF PERENNIAL FORAGE GRASSES

Leader: W. H. Mitchell, Chairman, Regional Technical Committee

Cooperators: The Agricultural Experiment Stations of the 12 Northeastern States, the U. S. Regional Pasture Research Laboratory, the Forage and Range Research Branch, ARS, and the Cooperative State Research Service, USDA

The project is concerned with the effects of management and environment on the morphological development and growth rate of perennial forage grasses, factors which influence the accumulation and depletion of food reserves, and the nutritional value of forages grown under specific management systems.

Growth chamber studies with timothy, Kentucky bluegrass, orchardgrass, and bromegrass have shown that ambient day temperatures of 65 to 71°F favored the first three grasses; whereas temperatures of 65 to 77°F were more favorable for bromegrass. As temperatures were increased from these optimum levels to 95°F, the growth of all species decreased. In other investigations, ambient air temperatures correlated poorly with growth

rates of Climax timothy and reed canarygrass, although a significant correlation was shown between spring growth rates and soil temperature.

A unique facility was further developed and utilized (Maryland) for controlling and measuring soil temperatures. Plant responses were large, with total dry matter ranging from 1.7 tons per acre for Climax timothy grown at a soil temperature of 32°C, to 5.2 tons per acre of S-37 orchardgrass grown at 10°C. The morphological development of each of the grasses tested was shifted by the temperature at which it was grown. As an example, S-37 orchardgrass which normally matures about ten days later than Potomac orchardgrass was made to flower at the same time by increasing the soil temperature.

Seasonal variations in the carbohydrate reserves in Climax timothy were studied at five levels of nitrogen fertilization. As the nitrogen rate increased there was a corresponding decrease in carbohydrate reserves. A sudden drop in reserves was associated with a sharp rise in soil temperatures following harvest. The maximum soil temperature one day prior to harvest was 71°F as compared to 83°F on the day following harvest. Tissue from plots receiving no nitrogen was consistently higher in reserve carbohydrates than that from fertilized areas, although the soil temperature in control plots was generally higher than in treated areas. In other studies it was shown that the level of carbohydrate reserves varied greatly among species and that the most important factor affecting the level of reserves in a particular species was night temperature. There was a general decrease in reserves as the night temperature was increased from 35 to 65°F.

A close relationship was found between biological and chemical measurements of carbohydrates in reed canarygrass. This relationship was distinct during spring growth but did not persist beyond the boot stage, at which time large increases in new rhizomes were noted. This suggested that in order to evaluate reserve carbohydrates the quantity of rhizomes as well as percent of carbohydrates must be known.

The height of the apical growth of Climax timothy at the first harvest had a pronounced effect on persistence. Harvesting when the stem apex was twelve inches above the ground (boot stage) was the most injurious treatment in terms of persistence; whereas, harvesting when the growing points were two inches high or after emergence produced the least injury. No damage to reed canarygrass stands was evident under any management treatment.

The nutritive value of forages produced under the harvest schedule of the previous NE-29 project was assessed in cooperation with the NE-24 group. Digestibility and intake trials were conducted with Climax timothy using sheep as test animals.

Frit fly infestations of reed canarygrass resulted in a yield reduction of .24 tons per acre at the second harvest (Connecticut). Insect control resulted in yield increases of up to 32%. Infestation interrupted normal morphological and physiological development and it is suggested that the residue left by the larvae may affect the acceptability of reed canarygrass by grazing animals.

USEFULNESS OF FINDINGS:

A basic understanding of perennial grasses has been enhanced by morphological and physiological work. A more quantitative approach to growth and development is essential if the myriad of management problems confronted by livestock men are to be resolved by something better than trial and error.

Title: PROJECT NE-45 - THE ROLE OF FUSARIUM SPP. AS CROWN AND ROOT PATHOGENS OF FORAGE LEGUMES

Leader: H. W. Crittenden, Chairman, Regional Technical Committee

Cooperators: The Delaware, New Jersey, Massachusetts, New York, Pennsylvania, Rhode Island, and West Virginia Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, the Forage and Range Research Branch, Crops Research Division, ARS, and the Cooperative State Research Service, USDA.

This project was revised and effective July 1, 1966.

Objective 1: To investigate the pathogenic potential of Fusarium spp. as influenced by the physical and biological environment.

Rhode Island reports on the potential of the Rhizobium-Fusarium antibiosis interaction on alfalfa root infection. In Fahraeus cultures F. oxysporum and F. roseum avenaceum in the absence of R. meliloti develop mycelium over the root surface which induces twisted root hairs with apical swelling on DuPuits and Narragansett. The presence of the fungi reduces the number of effective N-fixing nodules. If Rhizobium colonizes the root surface first, the fungus infection is inhibited. Root exudates stimulate the growth of both Rhizobium and Fusarium.

The report from Pennsylvania states that alfalfa grown in autoclaved and chemically-sterilized soil versus field soil has shown that the normal soil microbial population can influence the pathogenicity of Fusarium species being tested. When F. tricinctum was introduced into treated and field soil, alfalfa roots grown in the field soil were reduced in dry weight by one third. Further investigations have shown interactions between F. tricinctum, Rhizoctonia spp. and a bacterium isolated from diseased alfalfa roots. In all cases the disease was more severe when the mixture of microorganisms was used than when a pure culture of one was used.

Effect of Sitona hispidula on colonization of alfalfa by Fusarium oxysporum f. medicaginis in DuPuits alfalfa was studied at the Pasture

Laboratory. Data indicated that S. hispidula aided the colonization of roots by the fungus. The fungus caused a greater loss of plants than did S. hispidula, but plant depletion by either organism was significant. Plant depletion by these organisms in combination was not greater than the sum of the individual effects.

Two factors of the physical and biological environment used by Delaware investigators were potassium chloride and the root-knot nematode Meloidogyne incognita acrita. DuPuits roots (4-year old) inoculated with F. oxysporum and then subjected to the nematode and the KCl were noted to have a healing effect by an extra production of cells in the periderum region which tended to close the inoculation hole.

A contribution to the regional project from New Jersey involved Pennscott red clover which was subjected to four clipping-frequency treatments (one, two, four, and eight cuts). Among root isolates of Fusarium, the species oxysporum, solani, and roseum, were recovered in that order of frequency. Analysis of data indicated that clipping-frequency increased the severity of root rot as well as numbers of Fusarium species.

Preliminary tests in West Virginia were on Pennscott red clover infected with red clover vein mosaic virus and also inoculated with several different isolates of Fusarium spp. Results showed that greater number of plants were killed when the virus and certain isolates of Fusarium spp. were used in combination than either alone.

Objective 2: To investigate the suscept-pathogen interactions.

Roots of alfalfa seedlings grown 2 to 3 weeks under aseptic conditions in perlite in New York and then inoculated with Fusarium solani were analyzed after 10 days for pectolytic and cellulolytic enzymes. Healthy and diseased roots did not differ significantly either in pectin methylesterase activity (PME) or in their pectin content. Since F. solani in vitro produces little or no PME whereas healthy seedlings are high in PME activity, the activity of this enzyme associated with diseased tissues appears to be of host origin. Though alfalfa root cultures of Fusarium spp. were found to contain both endo-polygalacturonase (endo-PG) and endo-polygalacturonate trans-eliminase (endo-PGTE) enzymes, diseased tissues contained only the endo-PGTE enzyme. Roots of healthy seedlings lacked both enzymes. The endo-PGTE from diseased roots was characterized by a positive test for reduction in viscosity of pectin and sodium polypectate only at alkaline pH, the production of a reaction product that absorbed maximally at 230 m μ when polygalacturonic acid was the substrate, stimulation of activity by Ca $^{++}$, a positive thiobarbituric acid test, and maceration of potato slices at alkaline pH. There was a significant decrease in pectic acid content of roots of diseased seedlings compared with that of roots of healthy seedlings which suggests the involvement of endo-PGTE in cell wall degradation in diseased roots. In addition, extracts of diseased roots, but not those of healthy roots, had high levels of cellulase activity.

Analysis of selected enzyme production by pathogenic and nonpathogenic isolates of Fusarium from alfalfa roots have not shown a correlation with the enzymes studied and virulence in Pennsylvania tests.

At the Pasture Laboratory a histological study of internal breakdown (IB) in crowns of red clover plants revealed that starch was deficient, cytoplasm dense, and cell walls often thickened. Dissolution of middle lamellae, collapse of cells, and the occurrence of giant cells were associated with various stages of IB development. These conditions could contribute to colonization by Fusarium spp.

DuPuits (4 year old roots) inoculated with F. oxysporum f. batatas showed a greater amount of root decay in periderm, phloem, and xylem than roots inoculated with F. roseum. This difference was noted in both the transverse and longitudinal planes. The amount of decay in both planes increased with increase of time (1 to 3 months) with F. oxysporum f. batatas whereas after an initial decay by F. roseum, the fungus progression appeared to stop (Delaware).

USEFULNESS OF FINDINGS:

Some factors of the physical and biological environments which strongly influence the pathogenic potential of Fusarium spp. have been elucidated this year. The nature of selected interactions between susceptible and pathogen has been clarified. As this information accumulates it can be utilized by pathologists and other scientists to obtain forage legumes with better resistance to Fusarium spp. The data can be applied by extension pathologists and other workers to insure better cultural controls to be recommended to growers of forage legumes.

PASTURE RESEARCH AT STATE STATIONS

CONNECTICUT (STORRS)

Title: PLANT POPULATION FOR ALFALFA

Leader: D. D. Wolf

Vernal alfalfa was established in 3.5, 7.0, and 14.0 inch rows in pure stand and in mixture with overseeded Masshardy orchardgrass. The alfalfa was thinned in the seedling stage to population levels of 1, 2, 4, 6, 10, and 16 plants per square foot and subsequent populations and yield levels determined.

Actual populations one year after planting averaged 0.9, 1.4, 2.8, 4.2, 7.2, and 9.7 plants per square foot, respectively, for the population levels originally established. Maximum yields of pure alfalfa stands were obtained with an initial seedling population of 6 or more plants per square foot. In the mixed stands, however, highest yields were obtained with an initial alfalfa seedling stand of 10 or more per square foot. Yields were highest with the alfalfa seeded in rows 3.5 or 7 inches apart.

Title: EVALUATION OF HERBICIDES FOR CONTROL OF WINTER WEEDS
IN ALFALFA

Leaders: R. A. Peters, R. M. O'Leary, and W. L. Currey

White cockle (Lychnis alba) was found to be rather resistant to all herbicides evaluated. Bromacil, terbacil and simazine did cause marked repression of growth and chlorosis as well as prevention of flowering. At the same time, these chemicals provided excellent control of common chickweed (Stellaria media) and Shepards purse (Capsella bursa-pastoris). The generally poor control of over-wintering weeds in alfalfa that has been previously noted from 2,4-DB applied in the spring was confirmed.

Paraquat is a very active compound showing some indication of translocation in addition to top kill of deep-rooted weeds. It has marginal selectivity on alfalfa, however. Low rates of bromacil gave severe injury to alfalfa.

Terbacil is not desirable for alfalfa-forage grass mixture. It readily killed orchardgrass, a grass relatively resistant to most herbicides. Simazine has the advantage of removing bluegrass without injury to orchardgrass.

DELAWARE

Title: A STUDY OF THE INFLUENCE OF CUTTING HEIGHTS, NITROGEN FERTILIZATION, AND IRRIGATION ON PLANT SURVIVAL AND THE ROOT AND DRY MATTER YIELDS OF ORCHARDGRASS

Leader: W. H. Mitchell

Split applications of nitrogen produced the highest dry matter yields but this treatment was associated with later stand depletions, which in some cases exceeded 90%. Irrigation resulted in significant dry matter yield increases but it interacted with nitrogen and cutting heights to deplete stands. In comparing 1- and 3-inch cutting heights, the latter consistently produced a lower yield of dry matter on a seasonal basis. This response was reversed at the second harvest which is explained by the delayed recovery resulting from removal of apical growth at the 1-inch cut. Regrowth was achieved by the growth and development of basal buds as opposed to the elongation and development of flowering shoots under the 3-inch harvest. Root growth was depressed by nitrogen applications, irrigation treatments, and 1-inch cutting heights.

These data help to explain stand losses under clone grazing and heavy nitrogen fertilization. They suggest that surface irrigation restricts root growth and encourages weed competition, both factors contributing to stand depletion.

Title: EFFECT OF TYPES OF ORGANIC MATTER ON ROOT ROTS OF LEGUMES

Leader: H. W. Crittenden

At the substation the following types of organic matter were incorporated into the soil during June and July in aluminum-bordered plots: nongerminated soybean seed; germinated soybean seed plus 10-month-old alfalfa plants; 10-month-old alfalfa plants; germinated soybean seed plus 10-month-old red clover plants; 10-month-old clover plants; germinated corn seed plus 10-month-old alfalfa plants; and, germinated corn seed plus 10-month-

old red clover plants. In August, Vernal alfalfa seed was planted in all the plots. Due to drought, seed did not germinate till mid-September. Results in November indicated that all plots having soybean seed incorporated into the soil were almost devoid of alfalfa plants due to root rot. Germinated corn seed was beneficial to alfalfa growth. A separate test has indicated soybean seed soil amendment to be beneficial to growth of barley.

The technique of incorporating organic matter into the soil is valuable as a research aid but not from a practical viewpoint.

Title: CONTROL OF INSECTS AND MITES ON SOYBEANS, ALFALFA,
AND CLOVERS

Leaders: W. A. Connell, D. MacCreary, P. P. Burbutis, D. F. Bray,
and K. S. Simpson

The previous field cage tests evaluated the larval feeding of the alfalfa weevil resulting from known numbers of fall- and spring-laid eggs. These tests showed that the injury per larva at the average time of first cutting (May 20) was highest in those treatments containing all or nearly all fall-laid eggs and lowest in those treatments where all or nearly all spring-laid eggs were added. The field studies in 1965 and 1966, employing cages but depending upon natural egg deposition, further confirmed these findings and indicated that a high percentage of the total feeding injury at the time of first cutting can be caused by the larvae originating from fall-laid eggs. The injury to alfalfa in northern Delaware does not appear to be related solely to the number of larvae present at the time of first cutting but rather to a combination of factors, which includes population size, winter survival of eggs and larvae, cutting time and, perhaps most important, the percentage of larvae nearing or attaining maturity before first cutting.

These studies show that for optimum alfalfa weevil control it is necessary to control adults laying eggs in the fall of the year, or to control their larvae.

MAINE

Title: ALFALFA SEEDING RATE ON GRASS ESTABLISHMENT

Leaders: R. F. Stafford and C. S. Brown

The study begun in 1965 (1965 Annual Report, p. 40) was continued. It measures residual effects of alfalfa seedling population on stands and yields of associated grasses. Climax timothy showed the least tolerance of the heavy seeding rates of Narragansett alfalfa employed the previous year. Saratoga brome and reed canarygrass proved intermediate, while Pennlate orchardgrass was outstanding in its capacity for vigorous growth even in the most densely sown alfalfa.

A new sowing was made in May 1966 to study the effect of seedling populations of Saranac alfalfa on establishment of timothy, brome and orchardgrass. The results were quite similar to those of the 1965 study. Timothy was severely depressed even at seeding rates as low as 4 pounds alfalfa per acre. Orchardgrass again proved exceptionally tolerant of alfalfa competition, under the high nitrogen level employed. The following data illustrate the differences observed among grass species:

Alfalfa seed rate lbs/acre	Alfalfa yield* tons d.m.	Grass yields (2 cuts) tons d.m.		
		Timothy	Brome	Orchard
0	—	1.34	1.90	2.36
4	1.58	0.46	0.94	1.58
8	2.01	0.27	0.78	1.07
16	2.47	0.19	0.49	0.57

* Average of 3 grass mixtures.

Title: PLANTING DATE - SEEDING RATE STUDIES WITH SUMMER ANNUALS

Leaders: A. J. Gay and C. S. Brown

The 1965 field experiment with Jap millet, Piper sudan, and Sweet Sioux sudan-sorghum (1965 Annual Report, p. 41) was repeated with modifications in 1966. Results paralleled those of the previous year. An early May seeding showed no yield advantage over late May, and resulted in a relatively severe weed problem which required herbicide application. On the other hand, seedings delayed until mid-June produced only modest amounts

of aftermath before frost. Total dry matter yields at the higher seeding rates, averaged for 3 species, were as follows: 3.70 tons from May 2 seeding; 3.74 tons from May 23 seeding; 3.18 tons from June 13 seeding.

A study of the interrelationship of plant population and harvest stage on first crop yields of Piper sudan was also carried out in 1966. Seeding rates from 10 to 80 lbs per acre were used to achieve plant populations ranging from 6 to 28 plants per square foot. Maturity stages at first harvest were vegetative (18-24"), early boot, and full head. Yield responses were obtained up to the highest seeding rate with both the vegetative and early boot harvests. The delayed harvest at full head showed no yield response above 10 plants per square foot (20 pounds seed per acre).

Title: SOIL-PLANT-ANIMAL INTERRELATIONSHIPS IN PHOSPHORUS METABOLISM

Leaders: W. P. Apgar, B. R. Poulton, and C. S. Brown

The experiment conducted in 1965 (1965 Report, p. 41) was continued in 1966. The high phosphorus blocks of Climax timothy were topdressed with additional fertilizer P (600 lbs P₂O₅) in an attempt to further widen the range in P content among the lots of hay previously receiving low, medium and high P fertilization.

Phosphorus concentrations in the forages harvested in mid-June, 1966 were: low P, 0.20%; medium P, 0.27%; and high P, 0.34%. Winter feeding trials were conducted with sheep, using these three forages along with a treatment consisting of the low P forage supplemented with monosodium phosphate in amounts to make the phosphorus intake equal to that on the high P forage.

Mean DM intakes per 100 lb body weight and digestibility of dry matter (DDM) for these forages at maintenance and ad libitum levels of intake are summarized below:

	<u>At maintenance intake</u>		<u>At ad libitum intake</u>	
	<u>DM intake</u>	<u>DDM</u>	<u>DM intake</u>	<u>DDM</u>
	lb/cwt	%	lb/cwt	%
Low P	1.37	66.2	2.12	64.4
Medium P	1.42	66.1	2.18	65.8
High P	1.42	65.7	2.00	63.5
Low P + supplement	1.44	67.3	2.12	62.3

There were no statistically significant differences among forages with respect to dry matter intake or digestibility at the maintenance or ad libitum levels of intake. These results confirm those of the previous year's study. Determination of phosphorus and calcium balance is currently in progress.

MARYLAND

Title: RED CLOVER BREEDING INVESTIGATIONS

Leader: E. H. Beyer

Selected red clover plants were obtained from a polycross planting in the greenhouse and transplanted into the field to be used as a source nursery for improving red clover persistence as well as other desirable agronomic characteristics. Chesapeake red clover continues to be the best variety for Maryland.

Many red clover plants were crossed with those of Egyptian and Zigzag clover in order to improve the technique of intergeneric hybridization as well as introducing desirable germ plasm from these latter two genera into red clover adapted to Maryland.

Title: EVALUATION OF FORAGE SPECIES AND MIXTURES FOR
HAY PRODUCTION

Leader: A. M. Decker

The hay production of Williamsburg alfalfa, alfalfa-grass, Chesapeake red clover, red clover-grass, and pure grass stands have been compared during the past two growing seasons. Saratoga brome grass and Climax timothy were grown with both legumes and reed canarygrass was grown with alfalfa. Pure stands of grasses compared were Saratoga, Lincoln, Climax, Clair and common timothy.

Yields of either legume were increased by approximately one ton when grown with a grass. During the first harvest season the two varieties of brome grass were the most productive. They were less productive than either the legume or legume mixture the next year even with 200 pounds of nitrogen per acre.

Red clover mixtures were as productive as alfalfa the first year but yielded one fourth less during the second harvest year. This demonstrates that red clover is competitive with alfalfa on a short-time rotation.

Title: EFFECTS OF HARVEST FREQUENCY AND NITROGEN FERTILIZATION ON YIELD AND DIGESTIBILITY OF MIDLAND BERMUDAGRASS HAY

Leaders: A. M. Decker, R. W. Hemken, and N. A. Clark

Midland bermudagrass was fertilized with 0, 200, 400 and 600 pounds of nitrogen per acre and harvested 4, 5 and 6 times during the season. Dry matter yields and nitrogen recovery are being determined for each harvest on all plots. Feeding data are being obtained for selected treatments. Preliminary feeding trials indicate a large increase in digestibility with earlier harvested Midland hay.

Title: SOD SEEDING ESTABLISHMENT STUDIES

Leader: A. M. Decker

Crownvetch sod-seeded into bluegrass pasture gave yield increases equal to those obtained by complete renovation of the pasture to orchardgrass-ladino clover (1965 Annual Report, p. 42-43). Birdsfoot trefoil sod-seeded into the same pastures increased yields but these increases were significantly less than for crownvetch or complete renovation.

Earlier research at Maryland has demonstrated that the production from Midland bermudagrass pastures can be nearly doubled by sod-seeding cool-season annuals into the existing sward. Preliminary data from 1966 harvest season indicate that the seeding of cool-season perennials is no more productive than the annuals and much more difficult to manage. This comparison will require one or more additional growing seasons for evaluation.

Title: DIFFERENTIAL HARVESTING MANAGEMENT OF RED CLOVER AND RED CLOVER-TIMOTHY STANDS UNDER THREE LEVELS OF FERTILIZATION

Leader: A. M. Decker

Red clover and red clover-timothy mixtures cut at the early bloom stage of growth were higher yielding than when harvested prior to bloom or at the late bloom stage (see 1965 Annual Report, p. 43). Feeding value of the early cut material appeared to be superior to the late cut forage. However, there was only a small difference in crude protein. The stand lives of red clover or red clover-timothy mixtures were not shortened by early harvesting of the crop. Timothy seeded with red clover substantially increased forage yields. Where red clover stands were light because of dry weather following fall seeding, timothy filled in to maintain yields. There were also fewer weeds in the clover-timothy mixtures than with clover alone. Forage yields were slightly higher when fertilized according to soil test recommendations but stand persistence was not increased by fertilization.

Title: RESPONSE OF MIDLAND BERMUDAGRASS TO TWO SOURCES OF NITROGEN, THREE RATES OF NITROGEN, AND THREE LEVELS OF LIME

Leaders: A. M. Decker and J. H. Axley

Because of continued yield responses to residual nitrogen all plots were again harvested to measure the residual treatment effects for the second year (1964 Annual Report, p. 38 and 1965 Annual Report, p. 45). Yields ranged from 0.22 tons where no lime had been applied over the past years and where 1800 lb of N had been applied annually for the first two years to 1.51 tons where the same amount of N was used but where lime had been added. The pH in some of these plots was 4.0 or lower. The check plot which had no nitrogen or lime applied had a pH of 6.0 to 6.5 and produced 0.47 tons of dry matter. None of these plots received fertilizer or lime in 1965 or 1966. Nitrogen recovery data are being calculated along with dry matter yields and soil pH and nutrient status.

Title: PASTURE EVALUATION USING BEEF STEERS

Leader: A. M. Decker

Beef production on pasture can be substantial even in a dry season as 1966 (1965 Annual Report, p. 47). Gains were good on all Midland bermudagrass pastures but yields ranged from 483 pounds beef per acre with 200 pounds of nitrogen as fertilizer and no grain supplement to 885 pounds with 400 pounds of nitrogen plus light grain feeding (seven pounds per day per 100 pounds of body weight). The effects of nitrogen fertilizer and grain were additive. Beef gains produced by nitrogen were more economical than those produced by grain feeding. Slaughter grades taken at the end of the study showed an increase due both to nitrogen fertilizer and to grain feeding. The latter was much more important showing an increase of 1.9 points with only 0.4 points increase for fertilization. Increased production per acre was due both to higher carrying capacity and improved individual animal performance. This was true for both nitrogen fertilization and grain feeding.

Title: SUMMER ANNUAL FORAGES FOR DAIRY COWS

Leaders: R. W. Hemken, J. H. Vandersall, and N. A. Clark

Studies comparing pearl millet with sudangrass, with emphasis on the fat depressing qualities of pearl millet on dairy cows, is being continued (see 1965 Annual Report, p. 47). Treatments consist of high lime and potassium fertilizer vs neither lime nor fertilizer. The severe drought reduced plant growth, but early growth of the limed and fertilized pearl millet depressed butterfat more than that not limed or fertilized.

Title: CROPPING SYSTEMS FOR DAIRY FARMS

Leaders: J. H. Vandersall, R. W. Hemken, and N. A. Clark

In the second lactation of a three-lactation study in the Department of Dairy Science, cows produced as well when corn silage was the only forage fed as when they were given a forage ration of half corn silage and half alfalfa hay. Both groups averaged nearly 14,000 pounds of milk and over 500 pounds of fat on these all-year stored forage feeding programs. Cows that received a limited amount of corn silage (0.9 lb of silage dry matter per 100 lb of body weight) did not show the depressed fat percentage exhibited by those limited to a like amount of alfalfa hay in this lactation although they did during the first lactation.

Companion studies with corn and alfalfa are being conducted by the Department of Agronomy (see 1965 Annual Report, p. 46). This work was seriously impaired by the drought this year. When corn and alfalfa were irrigated, the corn responded with an increase of 80-100 bushels per acre while irrigation contributed to an almost complete loss of the alfalfa stand.

Title: CORN SILAGE STUDIES

Leaders: N. A. Clark, R. W. Hemken, and J. H. Vandersall

This study is being conducted in two phases: (1) A small plot study in which twelve varieties are being studied to determine their ripening characteristics and response to high and low populations. (2) A feeding study in which two varieties are grown at high and low populations in order to affect ear to stalk ratio, and ensiled at two dry matter levels, and fed to steers in intake and digestibility studies. Feeding is still in progress, and based upon results obtained, plans will be developed to feed different lots of silage to milking cows in 1967-68.

Title: RESISTANCE TO SCLEROTINIA TRIFOLIORUM ERIKS. IN SELECTED ALFALFA CLONES AND POLYCROSS PROGENY

Leaders: E. H. Beyer, J. H. Elgin, Jr., and O. D. Morgan

The above is a continuation of work started by Drs. O. D. Morgan and E. H. Beyer (1964 Annual Report, p. 40-41).

Eighty-two alfalfa clones were selected from the three populations Medicago sativa var. gaetula Urb., M. sativa L. cv. Narragansett and M. tianschanica Vass. Each of the three populations were intercrossed. Polycross seed from each maternal clone and cuttings from each clone were evaluated for resistance to Sclerotinia. Highly significant differences in clonal reaction occurred. Eleven of the clones showed good resistance to the fungus. Significant differences were observed among polycross lines when correlated with the means of the clonal evaluation.

Title: SPECIES OF MEDICAGO SCREENED FOR RESISTANCE TO SCLEROTINIA

Leader: O. D. Morgan

Seed of nineteen species of Medicago were obtained from the Plant Introduction Center, Experiment, Georgia. The original source of the species was from outside the United States including the countries of Greece, Turkey, Spain, Uruguay, Poland, Yugoslavia, Denmark, England, Afghanistan, Iran, Australia, Portugal, Argentina, Austria, Algeria and Morocco. However, not all species were obtained from all countries. All the species were screened against a mixture of Sclerotinia species and selections. Observations indicated that only 3 species, M. polymorpha, M. arabica, and M. lupulina showed a high degree of survival. Source of seed appears to have an effect on survival, for example, M. polymorpha showed good survival from 2 sources and all died from a third source. M. arabica showed good survival from three sources while M. lupulina survived well from one out of five sources.

Title: PREDATOR RESPONSE TO APPROVED INSECTICIDES FOR ALFALFA
WEEVIL CONTROL

Leaders: J. W. Neal and R. M. Coan (USDA)

Seven materials recommended or approved for use against the alfalfa weevil were compared on plots of 100 sq. ft. with each treatment replicated 4 times. The materials, with rates as lbs. per acre, were Guthion (3/4), Imidan (1), Methoxychlor (1-1/2), Sevin (1), Malathion (1-1/4), Parathion (1/4), and Diazinon (1), and they were applied on May 4, 1966. Surveys were made with a D-Vac device and by sweeping at intervals of one and three weeks following application. Three groups of predators were studied: coccinellids, damsel bugs, and spiders. Predators originally considered but completely absent or present in very small numbers were: soft winged flower beetles, big eyed bugs, lacewings, minute pirate bugs, and ground beetles. The results indicate that one of the insecticides was selective for an insect predator. However, native species of spiders appear to be the only predators which are active in substantial numbers following a chemical treatment. Migration of coccinellids into the field was demonstrated in the second sweep-net survey. No coccinellid larvae were taken at any time. The damsel bug population remained low throughout surveys.

Title: INSECTICIDAL CONTROL OF THE ALFALFA WEEVIL

Leaders: R. M. Coan and C. C. Blickenstaff (USDA)

Small plot tests were conducted at Beltsville, Maryland, in which 28 experimental materials were compared with a methoxychlor-malathion standard. Applications were made in May, 1966. Materials which prevented less than 5% weevil damage on foliage 20 days after application, and rates as lbs. per acre of actual material were: Bayer 39007 (1), Bayer 29493 (1/2), Stauffer N-4543 (1), Phorate (1), Geigy GS 13798 (1), Shell SD 7438 (1), Allied GC 6505 (1), and Sevin 80s (2). Other materials which reduced damage to less than 10% were: Niagara 10242 (1/4), Allied GC 3707 (1), Hercules 14503 (1), Chipman RP 11794 (1), Dioxathion (1-1/2), Bayer 25141 (1/2), and Methyl Parathion (1/4). The addition of Parathion to SD 7438 did not improve the control, nor did the addition of malathion to methoxychlor.

Title: OVIPOSITION STIMULANT IN ALFALFA AND SWEET CLOVER
FOR ALFALFA WEEVIL

Leaders: A. L. Steinhauer, H. D. Byrne, and C. C. Blickenstaff (USDA)

Of six legumes studied (alfalfa, white sweet clover, ladino clover, alsike clover, hairy vetch and red clover) only alfalfa and sweet clover supported oviposition at normal levels. The obvious difference in the number of eggs laid following feeding on alfalfa and sweet clover indicates the presence of an essential dietary component if the insect is to oviposit at the expected rate. This stimulant is nonolfactory in its behavior and it must be ingested continually to elicit an oviposition response. Weevils transferred from a good oviposition host (e.g., alfalfa) to a poor host (ladino) show an immediate decrease in their rate of oviposition.

Title: APPLICATION OF ENERGY FOR THE CONTROL OF INSECTS

Leaders: W. L. Harris, J. Neal, N. A. Clark, and C. C. Blickenstaff (USDA)

Flaming studies on control of the alfalfa weevil were conducted on a mature stand and a seedling stand of alfalfa (see 1965 Annual Report, p. 48). Flaming was effective in controlling the weevil and additional benefits of weed control on some plots were obtained. Flaming of dormant alfalfa or of alfalfa stubble immediately after harvest was not detrimental to the stand; however, flaming when 4 to 6 inches of growth was present was harmful to the alfalfa.

MASSACHUSETTS

Title: SEASONAL VARIATIONS IN CARBOHYDRATE RESERVES IN TIMOTHY

Leaders: W. G. Colby, Mack Drake, and David Field

During the 1966 growing season a study was made of seasonal variations in the carbohydrate reserves in timothy at five different levels of N fertilization in a two-year old stand of Climax timothy. Ammonium nitrate was applied at the rate of 30, 60, 90 and 120 lb N per acre. Muriate of potash was applied uniformly at approximately 125 lb rate in the fall of 1965 and again after the first cutting. There were four series of plots representing four different times of N application, viz, one on Nov. 15, 1965 and three the following spring, April 1, April 15, and May 1.

Samples for analysis for fructosan were taken at approximately weekly intervals from April 15 until the first cutting on June 23. Most plants had reached full bloom stage by this date. Samples were taken less frequently after June 23. Daily maximum and minimum soil temperatures at a 2-inch depth were recorded for May, June and July on the check plot and on the 60 lb N per acre plot. Only the results from the April 1 series are summarized in this report.

Rate of nitrogen fertilization.--An important finding was the pronounced effect of N fertilization. As the rate of N application increased, the level of reserve carbohydrates progressively decreased. Increases in yield were obtained with each added increment of N with the exception of the highest. Dry matter yields of hay were: check - 1170 lb; 30 lb N - 6930; 60 lb N - 8760; 90 lb N - 9700; and 120 lb N - 9970.

Temperature changes.--Minor fluctuations in reserve carbohydrate levels during May and June can be related to periods of warmer and cooler weather --the latter usually associated with the occurrence of rain. The major temperature effect occurred immediately following harvest on June 23, when levels of reserve carbohydrates fell drastically, and again during August when reserves increased sharply. The sudden drop following harvest, was due largely to a sharp rise in soil temperature following the removal of the hay crop. While the crop is still standing, it serves as an effective heat insulator to the soil. When the crop is removed, there is nothing to prevent soil temperatures from rising sharply if the weather is warm and dry. Soil temperature measurements showed that the maximum temperature at the 2-inch depth on the day before cutting on the 60 lb rate, was 71°F but on the day after cutting was 83°F. The average maximum temperature for the 14-day period before harvest was 67°F but for the 14-day period following harvest was 85°F.

If the weather during the 3 to 4 weeks following the first cutting is hot, timothy fertilized with moderate rates of N may show poor recovery growth. At heavy rates of N, extensive plant injury may occur and even loss of

stands. In our experiment recovery growth was retarded and some plants were injured on plots receiving 90 lb N per acre. On plots receiving 120 lb N, injury was severe and though some plants survived, a heavy invasion by crabgrass during July and August destroyed the stand. It is significant that the level of reserve carbohydrates fell to less than 3% in both the 90 and 120 lb N rates for the 3-week period after cutting on June 23. It is also important to note that there was no indication of plant injury, even at the highest N rate, prior to cutting. One series which was harvested a week later on June 30 gave no evidence of injury either until after harvesting.

An important point is the high level of reserve carbohydrates for the check plots throughout the growing season--even for the period following cutting. These high levels prevailed in spite of the fact that, because of relatively poor plant cover, soil temperatures in the check plots ran much higher in the period before cutting than in the N fertilized plots. For example, the average maximum soil temperature for check plots during the 14-day period before cutting was 75°F but for the 60 lb N per acre plot was 67°F. The explanation is largely in the low growth rate of the check plots because of soil N deficiency. Even though soil temperatures were high, deficiencies in soil N and possibly soil moisture restricted the growth rate so that carbohydrate reserves were not used up and the level remained relatively high.

The sharp increase in carbohydrate reserves during August is due to several factors, as lower soil temperatures from shorter and cooler days, and longer and still cooler nights, and lower levels of soil N after the growth of the hay. (No N was applied following cutting.)

It is concluded that carbohydrate levels are directly related to growth rates and any factor which affects growth rate such as, available soil N, temperature level, moisture level, etc., will affect the level of reserve carbohydrates.

Title: NUTRITIONAL EVALUATION OF FORAGES

Leader: H. Fenner

In past experiments with rumen fistulated animals, it was demonstrated that iso-butyric and iso-valeric acids up to certain amounts in silage are beneficial to the digestion of forages. In a survey of silages from different crops, we have found that high moisture silages, especially those made from early cut legumes and grasses, contain large amounts of these acids. Substantial quantities of n-valeric and n-caproic acids were also found. The concentration of these acids in high moisture silage is many times their concentration in the rumen of cows fed on all hay ration. There was up to 25 times as much isobutyric, 10 of iso-valeric,

25 of n-valeric and 250 times as much n-caproic acid. If it can be demonstrated that some of these acids actually have a beneficial effect on dry matter digestion, we may have to readjust our thinking on the actual feeding value of "smelly" silages; especially when they constitute only part of the ration and when the odorous components do not affect the quality or acceptability of products utilized. Generally high moisture silages have been characterized as poorly preserved, with objectionable odors, high dry matter losses, and low dry matter intake when fed as the sole ration. Recent indications are that dry matter losses have been overestimated with high moisture silages by as much as 10% largely because of methods used for determination. These included overdrying and the use of toluene.

Title: INVESTIGATIONS OF FORAGE CROP INSECTS IN
MASSACHUSETTS IN 1966

Leaders: F. R. Shaw, R. A. Callahan, and M. C. Miller

Abundance and seasonal distribution.--As one phase of the investigations of forage crop insects, extensive collections were made in Berkshire, Hampden and Hampshire Counties with supplementary collections in Franklin, Worcester, Plymouth, and Bristol Counties.

The most abundant single species was alfalfa weevil (Hypera postica). Maximum numbers were lower than in the previous year. Untreated fields had from moderate to severe damage, with many exhibiting a frosted appearance. Many fields were cut late, adding to the damage done by the weevil larvae.

Pea aphid (Acyrtosiphon pisum) was more numerous than last year, comprising 8.8% of the total; although slightly increasing it still has not attained a population of 45 to 60% of all insects as it had in earlier surveys. Beneficial insects were less abundant than last year, comprising .48% of the total versus .58% last year. Plant bugs remained approximately equal to last year's count, comprising 3.7% of insects collected. Leafhoppers at .8% of the total showed a sharp decrease from 3.81% the previous year.

A summary of the results of the survey is presented below. This report is based on collections of 22,182 insects taken from April 22 through June 24. Sampling was done by taking 100 sweeps with a 15-inch net in each field at approximately weekly intervals.

Census of Forage Crop Insects in Massachusetts

Insect name or group	Percent of total
Aphids	8.88
Plant bugs	3.72
Leafhoppers	0.80
Beetles:	
<u>Hypera postica</u>	82.98
<u>Sitona hispidula</u>	0.14
Elateridae	0.27
Other beetles	0.64
Meadow spittlebug (<u>Philaenus spumarius</u>)	0.87
Lepidoptera	0.23
Miscellaneous insects:	
Lygaeidae	0.004
Pentatomidae	0.01
Others	0.46
Beneficial insects:	
<u>Nabis ferus</u>	0.12
Coccinellidae (lady beetles)	0.35
Chrysopidae	0.004
Syrphidae	0.01
Related beneficial Arthropods:	
Spiders	0.41

Biological control.--Preliminary results of a two-year study of the effectiveness of Tetrastichus incertus and Bathyplectes curculionis on the alfalfa weevil indicate that T. incertus has greater control potential. While T. incertus attains above 90% parasitism, its peak period is approximately 20 days behind the peak alfalfa weevil larval population. B. curculionis reaches its greatest effectiveness during the peak of the alfalfa weevil larval population; but at only 30 to 60%, it does not attain the high parasitism of T. incertus, although it is as well dispersed. T. incertus maintained an average parasitism above 90% from June 29 through August 25, 1965, while B. curculionis ranged from 20 to 60% during the period from June 10 to June 25. T. incertus appears to be following the same pattern as last year.

Chemical control.--Evaluation of Sevin and Alfatox.--Four 38 x 14 plots were laid out on June 1. Two were sprayed with Sevin 80 S at 1.5 lb actual/acre and two with Geigy's Alfatox at 2 quarts/acre. Collections of 50 sweeps with a 15-inch net were taken from each plot on June 2, 6, 9, and 13 with two sets of 50 sweeps from an infested area in the field as a control. Analysis of variance (.05 probability level) indicated a significant difference between control samples and treated plots; but there was no difference between the treatments for larval, adult and total populations.

Evaluation of Thimet and Parathion Granules.--On May 11 three blocks were laid out; each containing a control plot and three treated plots, Thimet at 2 lb/acre, Thimet at 4 lb/acre, and Parathion at 1 lb/acre. Fifty sweeps were taken in each plot on May 18 and 25, and on June 1 and 8. Some phytotoxicity was noted at the 4 lb dosage of Thimet on May 18. Slight phytotoxicity was noted at the 2 lb dosage. On May 25 some phytotoxicity was still evident, particularly on the 4 lb dosage; but new foliage was normal.

No alfalfa weevil adults or larvae were found in any plots on May 18. For the last three collection days at two, three, and four weeks following application the treated plots all had a smaller alfalfa weevil population than the control plots (.05 probability level). On the third week after treatment the Thimet plots had significantly smaller alfalfa weevil population than the Parathion plots.

Efficacy of eleven experimental pesticides against the alfalfa weevil.--On June 28, 1966 thirty-six 20' x 20' plots of alfalfa were divided into three blocks of twelve plots each. Eleven pesticides were randomly applied to each block. One plot in each block served as a control. Compressed air sprayers were used to apply the insecticides as stubble sprays at the equivalent of 100 gallons per acre. Fifty sweep collections using a 15" net were made on July 5, 11, 18 and 25, 1966. A multivariant analysis for replicated data as described by Dixon and Massey was performed. Duncan's New Multiple Range Test as described by Steele and Torrie was performed to compare the efficacy of the different materials.

At the 0.05 confidence level Niagara 10242 1/2 lb actual/acre, Stauffer Imidan 1 lb actual/acre, and Niagara 10242 1.0 lb actual/acre gave the best, and statistically equal control. The combination Shell SD 7438 1/2 lb active and Methyl Parathion 1/4 lb active/acre; and Chipman RP 11974 1.5 lb active/acre were statistically equal but inferior to the first group. Geigy 13005 1/2 lb active/acre was inferior to the first two groups. The combination of Shell SD 7438 1/2 lb active/acre and Shell Methyl Parathion 1/2 lb active/acre or these two materials alone at same dosages were inferior to the first three groups and statistically equal. The fifth group consisted of Union Carbide's Sevin 80S 1-1/2 lb active/acre and Geigy's Alfatox using two quarts of the formulation/acre. These two were statistically equal to each other. The control plot contained higher populations than the treated plots and thus constituted the sixth isolated group.

NEW HAMPSHIRE

Title: BREEDING OF IMPROVED VARIETIES OF FORAGE SPECIES
ADAPTED TO THE NORTHEAST

Leaders: G. M. Dunn and L. J. Higgins

Two different trials comparing 15 diallel single crosses in bromegrass produced significantly less forage in Syn 2 than in Syn 1 (see 1965 Annual Report, p. 54). Differences between the two generations were approximately 0.3 - 0.4 tons/acre. Tests are underway to compare 3-, 4-, 5-, and 6-clone synthetics in Syn 1 and Syn 2 generations.

Additional segregation data were obtained in F₂ and F₃ for the "albino" mutant in bromegrass. Although ratios indicate possible tetraploid inheritance, this has not yet been demonstrated conclusively. Physiologic studies are underway with this mutant in growth chambers. It is also being used to study pollen distribution in a polycross nursery.

Seed was increased of New Hampshire red clover.

Title: COMPARISON OF CORN SILAGE AND CORN SILAGE-HAY ON
PRODUCTION IN LACTATING DAIRY CATTLE

Leaders: J. B. Holter and N. F. Colovos

The 4-year project is in its second year. All cows are fed corn silage (free choice) and concentrate according to milk production. The hay offerings are 0, 0.5, and 1.0 lb per 100 lb of body weight. Data are being taken on milk production, milk fat, solids-not-fat, milk protein, silage intake, herd health (including udder health), breeding efficiency, and the economics of corn silage vs hay. The effects of temperature and relative humidity on the above factors are being observed.

Plans are being made for a series of complete digestion and energy balance studies on all-corn silage rations, with corn harvested at 3 or 4 different stages of maturity.

Title: PLASTIC VACUUM STACK SILO FOR CORN SILAGE

Leaders: J. B. Holter and N. F. Colovos

The 100 T Seal-vac silo was filled with fresh, finely chopped corn (dough stage, nonfrosted), sealed, and evacuated on September 27, 1966. A tractor with buckets and weights was used to pack it. It was fed out beginning November 1, 1966. There were 258 degree-days during the first half and 3 degree-days during the second half of the 73-day feeding period in which the mean daily temperature exceeded 35°F. The total quantity of silage prepared was 92 tons and it contained 25.2% dry matter. The composition was: ash 1.52%, protein 2.18%, fat 0.55%, fiber 5.13%, and nitrogen-free extract 15.82%, all on the green basis. The loss during storage was 22.0% of the fresh weight and 18.0% of the dry weight. When the silo was first opened the silage appeared well-preserved and free of spoilage but within several days a large amount of grey and white mold developed which was sufficiently extensive to depress voluntary intake if the silage had been fed as the sole diet to lactating dairy cows. With the experience gained, spoilage losses should be reduced. It is concluded that the Seal-vac silo has value for mature corn silage on a temporary basis when production exceeds the storage capacity. At least two tons of silage should be removed daily. If a structure larger than a 100-ton capacity is needed, it should be longer but not wider.

NEW JERSEY

Title: HARVESTED FORAGE INVESTIGATIONS

Leaders: M. A. Sprague and B. B. Taylor

For the second year pure stands of orchardgrass (which had been grown with 25 and 125 lb of nitrogen fertilizer per acre plus 50 lb each of P and K) were harvested as the inflorescence emerged from the boot leaf. Cut forage was then ensiled in 1 ton plastic bags (1) immediately and directly behind the chopper, (2) after 5 hours drying in the swath and (3) after about 2 and 4 days drying in the field, and the silos contained forages of approximately 20, 40 and 60% dry matter, respectively. In addition 2 silos were constructed using a partial vacuum to aid in packing and filling. Each was sampled, weighed, stored for 5 months, opened, sampled again, and analyzed for losses during drying and storage. Determinations were made of dry matter, protein, hydrolyzable carbohydrates, fiber, volatile acids, volatile bases and total amino acids.

The data from the 1965 and 1966 silages suggest that the production of water during storage through chemical reactions is proportionate to the

breakdown of sugars and to total losses. Since the plastic film used was found to be slowly permeable to water, the use of another film is being explored. Partial drying in the field does result in sizable losses of feed nutrients, primarily hydrolyzable carbohydrates. Drier material does not ferment to as low a pH and so may lose less carbohydrates during storage. Up to 30% of the hydrolyzable carbohydrate was measured as lost during 5 hours drying of one unit.

The application of a vacuum had no measurable effect on preservation and on losses incurred. Some benefit from compaction of the forage was experienced but the procedure was costly and time consuming.

Protein losses were very low during field drying but the higher the protein content of the forage the greater the total loss of dry matter and of protein during storage. Chemical production of CO₂ during storage is measurable and accumulations are suspected of being directly related to dry matter losses.

Accuracy of weighing the forages in the field before and after storage has been identified as one of the largest sources of error in these experiments. Some improvements in techniques were made in 1966 and others are anticipated in 1967 which should remove a large portion of this error.

Title: RELATIONSHIP OF CLIPPING FREQUENCY TO
 ROOT DETERIORATION IN RED CLOVER

Leaders: Philip M. Halisky and Wasi M. Siddiqi

Pennscott red clover was established in spaced, 200-foot rows in 1965. In 1966 these plots were divided into eight replicates and subjected to four clipping-frequency treatments consisting of one, two, four, and eight cuts per season. The treatment period extended from May to September with appropriate cuttings being made at two-week intervals. The height of cut was 2-3 inches. In October clover roots from each replicate were dug, rated for severity of rotting, and subjected to standard laboratory isolation procedures. A sodium-azide rose-bengal agar medium was used for culturing fungi from diseased roots. From these isolations were recovered species of Fusarium, Rhizopus, Aspergillus, and Penicillium. Among isolates of Fusarium the species oxysporum, solani, and roseum were recovered in that order of frequency. An analysis of variance of the data indicated that the effect of treatments (clipping frequency) and that of Fusarium species recovered was statistically highly significant (Table 1). The effect of Rhizopus, Aspergillus, and Penicillium was not significant. According to the results, when clipping frequency was used as a stress factor both severity of root rot and numbers of Fusaria recovered from roots were significantly increased (Table 1). In these studies clipping frequency served as a useful

technique for inducing root deterioration in Pennscott red clover. In actual practice, a high frequency of clipping is comparable to excessive pasturing of clover stands. Both practices are detrimental from the standpoint of root rot development and subsequent stand depletion.

Table 1. Clipping frequency and root rot development in Pennscott red clover as related to numbers of *Fusaria* recovered from diseased roots.

Clipping frequency (No./season)	Average root- rot rating ^{a/}	Average no. <i>Fusaria</i> recovered ^{b/}
1 - cut	2.13	13.00
2 - cuts	4.60	23.50
4 - cuts	7.41	40.87
8 - cuts	9.08	50.49
LSD .01	1.47	9.68

^{a/} Scale used for rating root rot was 1-least to 10-most.

^{b/} *Fusarium* species recovered were oxysporum, solani, and roseum in that order of frequency.

Title: THE NUTRITIVE EVALUATION OF FORAGES

Leaders: J. L. Evans, M. W. Colburn, and C. H. Ramage

The number of forages evaluated nutritionally was increased to 17. Sixty-eight individual trials of about 40 days each for intake and digestibility studies were made. In addition 12 cafeteria comparisons using 42 individual trials were completed to determine the forage chemical characteristics which would give the largest intake of forage dry matter by growing steers. Dates of harvest of first-growth orchardgrass for two years were 5/11 (1), 5/18 (2), 5/25 (3), and 6/2 (4). Aftermath dates for orchardgrass were 6/24 and 6/29 with 41 days regrowth (5), 7/10 and 7/16 with 55 days regrowth (6), 8/21 and 8/28 with 41 days regrowth (7), 9/7 and

9/10 with 55 days regrowth (8). First-growth alfalfa was harvested 5/12, grown about 10-growth days south of the orchardgrass. Animal preferences were (a) alfalfa > 1, (b) 1 > 2, 3, 4, (c) 2 > 3, 4, (d) 1 > 5, 6, (e) 5, 6 > 2, (f) 5 > 7 > 6, 8 (g) 5 > 7, (h) 3 > 8 > 4, 6 (i) 8 > 4, 6.

Title: THE NUTRITIVE EVALUATION OF FORAGES

Leaders: J. G. Welch, Mrs. J. MacNamara and Mrs. P. Carter

The work is divided into two areas of investigation. The first is concerned with the determination of net energy content of three orchardgrass hays utilizing 36 lambs by the comparative slaughter technique. The three hays were common orchardgrass cut at three different stages of maturity with cutting dates of May 12, May 23, and June 1. Net energy for production, expressed in Kcal/kg dry matter, was 991, 611, and 570, respectively. Dry matter intakes for the 18 ad libitum-fed animals for the 141-day trial for the three hays were 1.12, 1.12, and 1.06 kg/day/lamb, or 81.1, 80.2, and 83.0 gm/kg.BW^{.75}/day, respectively. Digestible energy, metabolizable energy, and crude protein decreased with increasing maturity while cell wall constituents, acid detergent fiber, and lignin increased with advancing maturity.

The second area of investigation is concerned with the effects of undigestible fibers and particle size on voluntary consumption of hay by sheep. Thirty cm-long polypropylene fibers introduced into the rumen of wethers reduced intake and was associated with an increased digestibility of the hay fed. Limiting time of access to hay for polypropylene treated wethers caused a further decrease in intake. Feeding finely ground alfalfa (as alfalfa pellets) resulted in increased total dry matter intake by polypropylene treated wethers. Subsequent hay consumption levels were higher following removal of the alfalfa pellets from the ration.

Title: GRASSLAND INSECT INVESTIGATIONS

Leaders: S. R. Race and G. P. Dively

Two experiments were conducted to evaluate the effectiveness of recommended and experimental insecticides for control of alfalfa weevil in New Jersey. Ten insecticides were included in these experiments.

Results show that the insecticides recommended in New Jersey during 1965 and 1966 (diazinon + methoxychlor, malathion + methoxychlor, parathion,

and Guthion) are still effective and therefore, there is little need to change these recommendations during the 1967 growing season. Research was initiated to determine the distribution and winter survival of the overwintering stages of the alfalfa weevil in New Jersey. No results are available at this time.

NEW YORK

Title: BREEDING AND STRAIN EVALUATION ON FORAGE SPECIES IN NEW YORK FOR IMPROVED FEEDING VALUE, YIELD AND SEASONAL DISTRIBUTION OF FORAGE

Leaders: C. C. Lowe, R. P. Murphy, W. D. Pardee, J. T. Reid, M. J. Wright, and H. A. MacDonald

Alfalfa.--The 1966 growing season was favorable for alfalfa in New York. Spring growth was delayed by unusually cold weather but good first harvests were general for the state. Very little winterkill was reported; this was possibly influenced by below normal rainfall in 1965. Late summer rainfall and mild fall temperatures in 1966 resulted in excellent fall growth of alfalfa. A noticeable increase in harvest and utilization of this material by growers was observed.

Alfalfa weevil has spread over the entire state and is beginning to reach serious infestation levels in the major upstate and western production areas. Considerable difficulties were encountered in satisfactory control in both new and older infestation areas in 1966. This is believed due to effects of the abnormal weather pattern in prolonging the period of larval emergence. Currently used short residue-life insecticides were less effective than usual. Damage on regrowth after first harvest was often severe.

Two Narragansett-type varieties have been released by Cornell in 1965 and 1966. These are Iroquois, tested experimentally as WRN (wilt-resistant Narragansett); and Mark II, tested experimentally as HSN (high-seed Narragansett). These varieties have wide significance to the Northeast since they will probably replace Narragansett which has been the most important variety for more than a decade. Both varieties have been widely tested in trials in New York and throughout the region. A short description and summary of trial information accumulated at time of release is given below.

Mark II - is a 25-clone synthetic variety derived by selection for high seed setting ability within the variety Narragansett. Poor seed production has been a threat to stable seed supplies of this variety; Mark II was bred to give Narragansett performance and satisfactory seed production.

A previous experimental strain designated HSN was widely tested in Northeast trials from 1960-1964, and was superior in performance to Narragansett; it was not released due to temporary solution of the seed problem. Mark II contains parent clones of the earlier HSN strain plus additional selections which provide a wider genetic base.

Performance summary of Mark II alfalfa
(Data = average yields in tons/acre at 12% M)

No. of locations:	1st hvst. yr. prod. (9)	2nd hvst. yr. prod. (9)	3rd hvst. yr. prod. (6)
Mark II	4.57	4.64	4.03
Narragansett	4.39	4.62	4.07

Mark II has been equivalent in production to Narragansett over a wide range of environments.

Iroquois alfalfa was developed by three generations of backcrossing and selection. Vernal was the nonrecurrent wilt resistant parent; Narragansett, the recurrent parent variety. Large numbers of progeny were carried to provide a very wide genetic base.

1961-1966 Performance summary of Iroquois alfalfa at New York
and northeast locations (data = avg. yield in tons/acre at 12% M)

No. of locations:	1st hvst. yr. prod. (35)	2nd hvst. yr. prod. (21)	3rd hvst. yr. prod. (17)	4th hvst. yr. prod. (8)	5th hvst. yr. prod. (4)
Iroquois	4.49	3.35	4.10	3.64	3.42
Narragansett	4.39	3.40	4.04	3.41	2.75
Vernal	4.40	3.07	3.76	3.39	3.19

Iroquois has been clearly superior over both of its parent varieties.

Seed distribution in the Northeast for Saranac, a wilt resistant variety of the Flamande type, released by Cornell in 1963 exceeded 250,000 lb in 1966. Rapid expansion in use of this variety is anticipated.

Forage feeding value investigations.--Cooperative studies with the Department of Animal Husbandry have been continued on feeding value of forages. A study recently completed was comparison in intake and digestion trials with sheep of two varieties of different growth type (Cayuga and DuPuits) under two levels of harvest management intensity: 2 harvests and 3 harvests per season. Each harvest of each variety under each management was prepared and fed as a separate hay lot. Growing conditions, preservation and storage and feeding for total forage produced over a growing season were the same for both varieties. Replications were in animals per lot and in feeding trial environments. The study was run on both the first and second harvest years for the alfalfa stands. Results are being summarized for publication.

Feeding comparisons were also made in 1966 on sudangrass, hybrid sudan-grass and a sudan-sorghum hybrid fed in a sheep intake and digestion trial as ensilage preserved on two dates of harvest and as green chop material between the two dates. Ensilage preservation was in sealed plastic sleeves containing about 1-1/2 tons of chopped material. Handling methods were an adaptation from those developed by Dr. M. A. Sprague at Rutgers.

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS

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

Several large field source nurseries have been established in the search for resistance or tolerance to the alfalfa weevil and other characters. A few plants were noted that show some evidence of reduced weevil feeding. Greenhouse tests on eleven species of Medicago showed moderate to severe feeding damage on all of them.

A study of aneuploid alfalfa plants has shown that the extra chromosome in $2n + 1$ (33 chromosomes) plants is transmitted about equally through the egg or pollen. Crossing $2n + 1$ plants did not give any 34 chromosome plants. In an earlier study, a 46-chromosome plant was discovered that crossed with 32- and 33- chromosome plants and produced seedlings with 39 or 40 chromosomes. A number of 33, 39 and 40 chromosome plants are proving to be relatively fertile.

Work is continuing on the multifoliate character. Some stocks essentially breed true for this character but there is variation in expression with some plants showing multiple leaves only under certain environments while others may be almost entirely multiple-leaved from seedling stage on. An attempt is being made to develop lines that show a high degree of expression in the seedling stage so the character can be used as a marker gene for synthesis studies. In working with strains carrying this character, it is obvious that intensifying expression frequency is relatively simple but vigor, particularly seedling vigor, is lost in the process and is not

restored in any great degree by intercrossing of similarly derived plants or strains. A very similar pattern of behavior was encountered in selecting for a high degree of expression of the creeping-rooted character. A significant amount of inbreeding influence on vigor appears to be involved in close selection for expression of these single characters; a wide gene base and not intensifying specific character expression beyond practical levels seem to be necessary restrictions for breeding alfalfas with performance equivalent to our better wide-based varieties.

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. P. Murphy, R. R. Seaney, and W. D. Pardee

Two alfalfa synthetics carrying the creeping rooted character have been evaluated for two years under broadcast seeding competition in New York and other Northeast sites; no evidence of character expression has yet been reported. The vigor level of the synthetic derived from creeping and Flamande-type clones has been good; vigor exceeds the Ranger variety and general performance has been much above any previous creeper strains. The synthetic derived by cyclic selection in creeper populations is not equal to Ranger in vigor.

Cooperative trials at Pennsylvania and New York were established in 1965 and 1966 to study seeding rate adjustment procedures for experimental trials. High hard seed content of experimental lots grown in isolation cages or in field isolations in the Northwest is a problem because seed damage cannot be uniformly controlled with small lot scarifiers. Trial results indicate that hard seed has essentially zero planting value under establishment practices normally used with this crop. Results also indicate that measurable performance difference may exist between non-scarified quick germinating seed and quick germinating seed derived from a broken hard seed fraction for the same lot. Quality control on commercially processed seed is usually good and usual variety trial seeding rate adjustments are satisfactory with such lots--particularly if a more than adequate base rate is employed. Difficulties arise in comparing commercial lots and experimental seed lots which cannot be commercially processed. Most adequate procedure based on current information is to adjust experimental strain seed lots on a basis of quick germ only or if seed does not permit, to scarify and increase the normal rate on such disadvantaged lots. Experience has shown that seed lot differences are usually not expressed in all seedling environments but tend to show up in the less favorable situations when a trial series is planted across an array of environments.

Another interesting feature in the trial results is that above optimum seeding rates did produce a small but measurable difference in plants/

sq. ft. surviving through the seedling year in stands which could be considered near-perfect. These small differences in excellent stands were directly associated with measurable first harvest year yield differences.

Double cross combinations derived from 4 parent alfalfa clones and produced under isolation cages without pollination controls have been studied as an adjunct to synthesis studies conducted under regional project NE-28. These combinations have indicated that performance of the double cross definitely is influenced by the advanced generation single cross parent line seed fractions in the double cross seed mixture. Seed cage information where parent lines were harvested separately reveals that wide differences in seed production can exist between parent lines. Double cross performance from seed produced without pollination control is therefore a function of both parent line forage performance and seed production potential. If seed production potential of parent lines is influenced by seed production environment, variation in performance could result from different proportions of the several seed fractions in the double cross mixture if seed of both parent lines were bulked.

Title: RECORDING FIELD OPERATIONS AND OTHER SEASONAL EVENTS IN
AGRICULTURAL LANDSCAPES THROUGH REPEATED AERIAL PHOTOGRAPHY

Leaders: M. J. Wright, W. L. Griffeth, R. Feuer, and R. F. Lucey

It was found possible to study timing of operations, crop rotations, weed infestations, wildlife food and cover, farmstead organization, and other features of the landscape and land use by means of photographs. It was possible for an inexperienced crew to use the photographs quickly and to good advantage; this applied especially to the color photographs.

Three of four cooperating departments have completed studies dependent upon the photographs. A punched card deck tabulating data from all 4200 fields has been prepared. The participants have gained or improved a skill that all are likely to use again. On the negative side, no surveys of the kind explored here have yet been carried out elsewhere in the state.

Title: MANAGING ALFALFA FOR MAXIMUM YIELD AND PERSISTENCE IN REGIONS
 OF NEW YORK AND SIMILAR ENVIRONMENTS

Leaders: M. J. Wright, G. A. Maybee, and R. L. Millar

County extension agents were surveyed to determine present and expected management practices in their areas. Partially on the basis of this survey five management systems were selected to include present and future practices. Management systems adopted were:

1. 3 cuts (early), on June 1, July 15, and September 1.
2. 3 cuts (late), on June 10, July 25, and September 20.
3. 3 cuts (early), plus fall cutting to simulate grazing on September 20, and October 10.
4. 2 cuts, on June 20 and August 10.
5. 2 cuts, plus fall cutting to simulate grazing on September 1, September 20, and October 10.

Saranac, Cayuga, Narragansett, and Vernal were the varieties used.

Two locations of plots (Central Plain and Oneida-Mohawk Regions of New York State) were sampled for dry matter yield during 1966 according to the proposed cutting management systems. Stands of the alfalfa varieties at both locations were good. Soil samples were taken in autumn to assess the effects of management of soil fertility. Data accumulated during 1966 are presently being processed. Two more locations (Hudson Valley and Northern Regions of New York State) were reestablished. Stands in the new locations appear very good.

Title: MORPHOLOGICAL AND PHYSIOLOGICAL RESPONSES OF PERENNIAL
 FORAGE GRASSES

Leader: M. J. Wright

A study of Bromus inermis, parallel in some respects to previous work on P. arundinacea, was begun. In the initial phases clonal rhizome propagules were sketched, planted, and allowed to grow for three weeks and then re-examined. Nearly two thirds of the shoots that appeared during the three weeks arose from sites devoid of visible buds at planting. No rhizome growth occurred. Shoots tended to arise from close to the initial main shoot.

Defoliation studies confirmed the large contribution to stem elongation and growth in weight that is made by the upper blades. Because they were smaller, the basal blades were in some cases calculated to be more efficient. Other calculations indicated that blades increased in efficiency as adjacent blades were removed.

Under long-day conditions in the greenhouse, aerial stems tended to elongate indefinitely without flowering. In some pots the shoot grew to a height of over six feet and bore more than 40 blades. Tillers arising from the base of such stems flowered freely without a cold induction period. Investigation of this behavior was begun.

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

Leader: M. J. Wright

A study of the decomposition of 4- (2, 4-dichlorophenoxy) butyric acid under ensiling conditions was completed. Alfalfa sprayed with 2, 4-DB prior to ensiling in vials was allowed to ferment for various periods. Access of air and pH were regulated in some experiments. Gas chromatographic analysis of the silages indicated that appreciable decomposition of the herbicide occurred only under aerobic conditions. Herbicide residues of this kind are unlikely to disappear completely during ensiling, especially if recommended practices of rapid filling and complete exclusion of air are followed.

Title: INFLUENCE OF AGRONOMIC PRACTICES ON THE NUTRITIVE VALUE OF FORAGE CROPS

Leader: M. J. Wright

Efforts in 1966 were concentrated on developing suitable cultural and analytical techniques in connection with the study of nitrate accumulation in plants. A number of published methods for determining nitrate were compared for speed, accuracy and compatibility with a simultaneous determination of carbohydrate. A control-chamber hydroponic procedure was evolved for the production of uniform corn plants. Under the guidance of Dr. J. F. Thompson, Mr. F. W. Smith devised a leaf disc procedure for assay of nitrate reductase, and preparations were made for mass spectrometry of samples grown in N^{15} media.

Title: PESTICIDE RESIDUES IN OR ON RAW AGRICULTURAL COMMODITIES

Leaders: G. G. Gyrisco, D. J. Lisk, and T. K. Wood

In 1966, over 200 samples of experimental and labeled insecticides were taken in connection with the alfalfa weevil investigations to determine if there were any residues at harvest. Seven insecticides were sampled at weekly intervals from application to harvest. Disappearance curves were plotted from these. In most cases negligible residues were present at harvest from all the carbonate and organophosphorus insecticides tested.

Malathion and Guthion were applied as U.L.V. sprays from ground and air equipment. In general such sprays gave higher residues than similar amounts of insecticides applied as dilute sprays. Malathion residues ranged from 0.1 - 0.7 ppm with a mean of 0.35 ppm on alfalfa 13 days after treatment. Guthion residues ranged from 1.9 - 3.9 ppm in the same interval and averaged a high 3.20 ppm.

Studies of plants grown in soil treated with heptachlor and dieldrin revealed that translocation of these insecticides does occur. With the one-pound rate, dieldrin showed residues ranging from 0.05 - 0.18 ppm and averaged 0.124 ppm. Heptachlor epoxide residues from the one-pound rate translocated in the amounts of 0.03 - 0.19 ppm and averaged 0.120 ppm. From the 5-pound rates, translocation of heptachlor as epoxide ranged from 0.18 to 1.7 ppm and averaged 1.20 ppm; dieldrin gave residues ranging from 0.05 to 0.18 ppm with an average of 0.124 ppm.

Title: BIOLOGY AND CONTROL OF THE ALFALFA WEEVIL

Leaders: W. R. Cothran, D. J. Horn, and G. G. Gyrisco

During the spring of 1966, 30 experimental and labeled insecticides were field evaluated in some 90 dosages or combinations for the control of the alfalfa weevil. Of these, 24 insecticides gave controls of 90% or better in acute toxicity ratings--most exceeded 95% control. Among the most exciting of the "new" insecticides were Dow's Dursban at 4 oz/acre, Geigy's GS 13005, GS 13798, Ortho 9006, NIA 10242, GC 6506, N-4543, UC 20047 A, Hercules 14503, 14504 and Thiocron--all at one half to one pound per acre.

Cornell's current recommendation of a methoxychlor-malathion mixture gave controls ranging from 96-99% in six experiments where it had been included as a standard and applied at the 75% tip-feeding injury. Cornell's alternate recommendation of diazinon-methoxychlor also gave good controls ranging from 94-96% when similarly tested. Guthion, parathion, and Imidan, all presently labeled, were found to give good if not outstanding control.

Three different sampling methods were tested for ease and accuracy in sampling infestations of the weevil in the field. Of the three methods, square-foot sampling proved more accurate than sweep-net or vacuum-net collections but sweep-net collections yielded the best combination of ease of handling and accurate results. The spatial distribution of groups of larvae on alfalfa stems in the field fitted well to a Poisson series when simplified; this implies a random model and may lead to a method by which better timing of insecticide application for weevil control may be realized.

Biological control studies centered on the larval parasite Bathyplectes curculionis and Tetrastichus incertus. Recoveries of the former parasite at 1963 and 1965 release sites ranged from 5-20%. T. incertus was recovered in 30 counties in 1966 and probably present in 8 more. Parasitism by T. incertus ranged from 0 to 100% of the field collected larvae depending on the date or location of the sample. Intensive studies have been undertaken on the biology of T. incertus, especially the effects of environmental factors such as temperature and photoperiod on its life cycle.

Title: FLIGHT BEHAVIOR AND CONTROL OF THE EUROPEAN CHAFER

Leaders: R. J. Little Jr. and G. G. Gyrisco

Sampling of European chafer grub plots treated with Telodrin or dieldrin at 0.5, 1.0 or 3.0 pounds per acre on May 16, 1963 showed that all treatments were killing 100% of the grubs on November 13, 1966 when sampled over 3-1/2 years later.

In another experiment where 12 different insecticides were used at 4, 12 or 20 pounds per acre in April 1964, only dieldrin and HRS-1671 continued to give complete kills of grubs. Bayer 25141 and Bayer 37289 also showed excellent promise when sampled in November 1966. AC 4772, NIA 10242, UC 21149, UC 10854, and Mobil MCA-600 were intermediate and warrant further testing.

Further work was continued in the field on the spatial distribution of adult European chafers in the soil over a 24-hour period. It was found that it is possible for this nonfeeding adult insect to conserve its energy by remaining at a site where fluctuating temperatures would ordinarily require reorientation with its accompanying energy loss. Both males and females rest in the daytime in the upper inch of soil but may be found up to 3 inches in the soil.

The overall temperature preferendum of the adults was 75.45°F but this preference was found to fluctuate diurnally to the extent of 4.64°F in males and 2.89°F in females under dark conditions. Females were found

to be more active in a dark temperature gradient than in a light gradient whereas the males were equally active under both dark and light conditions. A smaller fluctuation in the order of 1.89°F for males and 1.69°F for females occurred for beetles exposed to low light intensity.

Title: RESISTANCE OF SEVERAL SPECIES OF FORAGE CROPS TO THEIR
INSECT PESTS

Leaders: D. J. Horn, R. P. Murphy, and G. G. Gyrisco

In laboratory tests, 27 commercial varieties and exotic varieties of alfalfa and related species of Medicago were screened for resistance to alfalfa weevil feeding and oviposition as follows: three to five adult weevils were caged on each of 25 seedlings of each variety; these fed and oviposited for one week. Measurement of resistance consisted of a visual estimate of adult feeding and a count of the number of weevil larvae hatching from eggs.

Of the several varieties tested two, Medicago carsteinsis and M. pironae, showed significant resistance to both adult feeding and oviposition when compared with susceptible commercial varieties on the basis of these tests. Some other varieties also gave low numbers of weevil larvae but these varieties were heavily damaged by adult feeding. It will be necessary to test further these and other varieties to definitely confirm these results.

A search of several weevil-infested fields in June and July failed to yield any clones of alfalfa resistant to normal weevil attack.

In the laboratory, thirteen commercial varieties of alfalfa were screened for pea aphid resistance; no appreciable difference in susceptibility was seen among these.

Title: A STUDY OF THE TRANSMISSION OF SEVERAL FORAGE VIRUSES BY
THE PEA APHID

Leaders: L. R. Nault, W. F. Rochow, and G. G. Gyrisco

Bradley's techniques were used to observe pea aphid and saliva sheathing. Sheath saliva after 156 probes (of the pea aphid on peas) initiated by starved aphids on the abaxial surface of pea leaves was found in 112 cases. Observations were divided into three classes: naturally terminated probes between 7 and 26 seconds (62 probes), artificially terminated

probes at 60 seconds (25 probes), and when "flange saliva" was found on the plant surface. The underlying epidermis and parenchyma was surveyed for further signs of sheath saliva. The salivary flange was found above the intercellular groove in 58 of 62 short probes. The adjacent cell walls often appeared to have been forcibly separated by the penetration of the stylets. An increase in the duration of probes resulted in an increase in the depth of the saliva sheaths. Further histological studies were made of stained leaf tissue.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF PERENNIAL FORAGE LEGUMES

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

Breeding of creeping-rooted alfalfa was continued. Intercross progenies of several combinations of selected F_1 plants from creeping rooted x hay type alfalfa have been made. A large nursery for the evaluation of F_2 progenies was planted in 1966. The attempt was made to establish populations with varying characteristics for reselection in recurring generations. Low overall frequency of vigorously creeping-rooted plants (about 12% of the total plants) in F_1 progenies was found. Strong selection pressure for high creep percentage will be necessary in ensuing generations. Marked differences among F_1 progenies in percentage creep suggest the existence of genetic differences for creeping-rootedness among parents. Outstanding creeping-rooted parents averaged 30% creeping-rooted plants in F_1 progenies.

A field trial to evaluate the effects of various methods of seed processing on stand vigor and yield of several alfalfa varieties was continued in 1966. Extreme drought in this growing season prevented critical evaluation of treatments. This experiment is in collaboration with the New York Experiment Station.

Forage yield and other characteristics of new varieties of alfalfa, red clover, and birdsfoot trefoil were measured in field experiments at three Pennsylvania locations. Drought effects minimized the value of 1966 data, although several new trials were successfully established for future study.

Title: CYTOGENETICS OF FORAGE CROP SPECIES AND INTERSPECIFIC HYBRIDS

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

Cytogenetic investigations of diploid Medicago have continued. Chromosome studies have been directed to the identification of the specific extra chromosomes of a series of trisomics derived in previous work. Studies of the pachytene meiotic chromosomes were initiated and preliminary observations indicated identification of different chromosomes possible.

Measurements of mitotic chromosomes of diploid M. sativa were accomplished for karyotype analysis. Excessive cell-to-cell variability in chromosome measurements was obtained when conventional root-tip squash methods were used. Pollen-tube preparations for observations of haploid nuclei indicated a better chance for success.

The genetic controls of several deviant characters are being studied in diploid M. falcata. A floral characteristic designated "spotted calyx" and a chlorophyll-less mutant causing lethality in the seedlings have been studied in early generations. Preliminary results suggest a simple genetic mechanism for the latter.

Species hybridization studies with red clover (Trifolium pratense) and T. pallidum were advanced. The sesquidiploid hybrid appears to be completely sterile. The meiosis of the hybrid has been analyzed, and high degrees of many irregularities were noted. The meiosis of triploid red clover will be studied in comparison with that of the hybrid. Embryological studies of the hybrid 2 X T. pratense X 2 X T. pallidum have been begun.

Title: THE GENETICS AND IMPROVEMENT OF PERENNIAL FORAGE GRASSES

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

Work continued in variety development in orchardgrass. Performance data were collected on the following breeding materials in several stages of evaluation:

- A. The polycross progenies of 45 clones selected at the USDA Pasture Laboratory for lateness in maturity and a high level of disease resistance: stress imposed by severe drought and disease resulted in a marked reduction in stands in certain progenies. Yields measured over three years indicate some superiority in performances of selected clones over check varieties.

- B. The polycross progenies of 23 medium late clones selected for disease resistance seeded in broadcast plots in 1965: no difference in stand nor disease reaction was noted.
- C. The polycross progenies of 236 clonal selections seeded in broadcast plots in 1965: satisfactory growth occurred only in the first harvest. Higher yields in certain selections over check varieties were noted.
- D. Experimental synthetics seeded in 1964: severe summer drought limited production in these trials after the first harvest.

Breeders seed nurseries were maintained for the orchardgrass varieties Pennlate and Pennmead. Syn 1 seed was harvested for each variety.

Reed canarygrass.--A space planted nursery was established using seed from a number of lines obtained from the Regional Plant Introduction Station.

Variety trials.--Trials of recently released varieties of several species were continued at three locations in the state. New seedings were made at two locations.

Title: BREEDING CROWN VETCH (CORONILLA VARIA L.) FOR FORAGE AND SLOPE STABILIZATION USAGE

Leaders: M. L. Risius, R. W. Cleveland, and J. L. Starling

Seeds of 26 domestic and foreign accessions of Coronilla were collected. A source nursery of 3,100 plants from 23 of these accessions was established. Plants will be evaluated for morphological characteristics and agronomic potential.

Plants exhibiting diverse morphological characteristics were selected from local plantings of Coronilla varia. Initial crosses were made among some of these plants to begin genetic studies on the type of inheritance that is characteristic for Coronilla varia.

Small plot seedings of existing varieties of crownvetch will be made to assess the potential and limitations of the species as a forage crop. Several cutting and fertility treatments will be imposed on these seedings.

Title: EVALUATION OF NEW FORAGE VARIETIES AND SPECIES FOR DAIRY PASTURES

Leaders: J. B. Washko, E. M. Kesler, and A. L. Haskins

The severe 1966 summer drought limited forage productivity of the various pasture swards in their 5th year of grazing. The double-cropped late summer seeded Balbo rye and the Suchow 34 sorghum-sudan seeded in the late spring outyielded the perennial swards for the first time since the inception of this experiment. This combination furnished 4.22 tons of dry matter for grazing and 513 cow days of grazing per acre. Productivity in tons of dry matter per acre and carrying capacity in cow days per acre of the other four pasture swards were as follows: Vernal alfalfa - Pennlate orchardgrass was second highest yielding with 3.91 and 329; Pennlate orchardgrass with nitrogen fertilization, 3.70 and 414; the Viking birdsfoot trefoil - Pennlate orchardgrass 3.39 and 431 and the ladino clover - Pennlate orchardgrass sward was least productive with only 2.50 and 242.

New Zealand rotational ryegrass alone and with white clover produced only 2.14 and 2.02 tons of dry matter per acre under simulated grazing conditions. This variety of ryegrass does not appear to offer promise for Pennsylvania conditions.

These data indicate the advisability of using more than one or two forage species for forage purposes. By utilizing several forage species for grazing the livestock producer can make better use of available soil moisture to obtain wider distribution of forage during the growing season.

Title: UTILIZATION OF FORAGE BY BEEF CATTLE

Leaders: J. B. Washko and L. L. Wilson

Forage production and carrying capacity of the pastures were markedly reduced by the severe 1966 drought. Forage dry matter yields in tons per acre averaged as follows: 2.49 tons for the cropland pastures, 2.07 for the mountain pastures, and 1.37 for the new pastures. These pastures were stocked with one mature crossbred cow and her calf, dropped the previous fall or winter, for each 3 acres of land. In addition to nursing the cow, calves had access to limited quantities of grain via creep feeders. Fifty-four calves on the cropland and new pastures gained 282.1 pounds or 1.93 pounds per day whereas 55 calves on the mountain and new pastures gained 289.2 pounds or 1.98 pounds per day over the 146-day grazing season.

This research indicates the feasibility of producing crossbred dairy beef in this state on land unsuited for crop production.

Title: BIRDSFOOT TREFOIL MANAGEMENT

Leaders: J. B. Washko and E. B. Jones

The effects of various cutting schedules on yield and stand survival of Viking and Empire birdsfoot trefoil were continued in 1966. Low total rainfall and poor distribution again resulted in low yields.

Five terminal harvest dates were compared by measuring etiolated regrowth in a dark growth chamber. In general, delaying the terminal harvest date in the fall decreased root reserves; however, there was evidence that some metabolic process was operating during the second week of September. It was later determined that rhizome initiation occurs at this time.

Both varieties were subjected to 3 different cutting management treatments. The first harvest in two treatments was taken when plants reached a 6-inch height with the following harvest removed each time plants reached 6 inches and at 5-week intervals. The first harvest in the third treatment was taken at 1/2 bloom with successive cuttings removed every 6 weeks.

Over all treatments Viking produced higher forage yield than Empire, and highest forage yields for both varieties were obtained when the first harvest was removed at 1/2 bloom and succeeding harvests every 6 weeks. The lowest yields for the Empire variety were obtained when the first harvest was taken as the plants reached a 6-inch height with successive harvests taken at 5-week intervals. The Viking variety yielded the least when both the first harvest and aftermath harvests were made when the plants reached 6-inch heights.

Five terminal harvest dates, at 1-week intervals during September, were again incorporated in the clipping treatments. Plugs from these treatments were taken when plants went into winter dormancy and placed in a dark chamber to measure carbohydrate reserves at dormancy via the etiolated regrowth technique. Samples were also taken for laboratory determination of carbohydrate reserves.

When the two varieties were subjected to various cutting schedules in the greenhouse during the winter of 1966, the forage yields followed the same trends as in the field experiment.

An additional field experiment which was initiated in 1965 was continued. A comparison of 16 seeding techniques utilizing band seeding and broadcast seeding with press wheels and various weights is being made. At this time results are not sufficiently complete to draw conclusions.

Title: EVALUATION OF SUDANGRASS AND SORGHUM-SUDAN HYBRIDS FOR FEED PRODUCTION

Leaders: J. B. Washko, W. L. McClellan, J. O. Yocum, and A. L. Haskins

Thirty varieties of summer annuals, sorghum-sudan hybrids, sudangrass hybrids, sudangrass, and corn were seeded for forage at Centre Hall, Landisville, Ligonier, and Towanda. Because of the severe drought and lack of soil moisture, the experiments at Centre Hall and Towanda failed to become established and had to be abandoned.

Highest forage yields of the summer annuals were obtained at Landisville because of higher rainfall. Pa 820 hybrid corn produced slightly more forage at Landisville than any of the sorghum-sudangrass hybrids. Dry matter production ranged from 3.60 tons of dry matter per acre for Piper sudangrass to 5.75 tons for Pa 820 hybrid corn. Dry matter production per acre for the 25 sorghum-sudan hybrids grown at Landisville averaged 4.94 tons.

At Ligonier forage production of the summer annuals ranged from 1.44 to 3.20 tons of dry matter per acre. Average dry matter production of the 25 sorghum-sudan hybrids grown at Ligonier was 2.18 tons per acre.

The experiment at Centre Hall was replanted on July 13 to determine how much dry matter these summer annuals would accumulate by the date of the first killing frost. Dry matter yields in this experiment ranged from .77 tons per acre for Piper sudangrass to 2.34 tons for Pa 602A hybrid corn. Dry matter production for the 25 sorghum-sudan hybrids in this late-planted experiment averaged 1.5 tons.

The severe drought also limited the forage production on the high population corn for silage experiment, cancelling out any effect that might be gained from high populations.

Title: MAINTENANCE FERTILIZATION OF GRASSLANDS IN PENNSYLVANIA

Leader: L. F. Marriott

Established stands of alfalfa at four locations in the state received topdressings of N at 20 and 40 pounds per acre. There was no significant difference for N at any location. Alfalfa and birdsfoot trefoil at the Southwestern Field Research Laboratory in the second year of treatments with N, P, K, B, and Mg showed no yield increase for N applications, and no significant differences for other treatments. Dry weather limited yields. In one experiment with birdsfoot trefoil, spring-applied N at 100 pounds per acre reduced yields and encouraged chickweed infestation.

A magnesium deficiency problem in Indiana County led to the initiation of a study on 8 fields of a cooperator's farm. Soil samples indicated some fields had low magnesium levels with correspondingly high Ca/Mg ratios. Treatments with limestone (calcitic and dolomitic) and with a magnesium fertilizer were made to approximate certain desired Ca/Mg ratios. Analysis of soil and plant tissue samples will be used to determine effects of treatments and to assist in determining future recommendations.

Title: PRODUCTIVITY OF FERTILIZED GRASSES

Leader: L. F. Marriott

Smooth brome grass seedings at two locations in the state received differential fertilizer treatments for the 1966 crop. There was a significant response to N, but not to P, K, or Mg. Dry weather limited yields.

Liquid manure from a steer feeding facility applied to orchardgrass at 10, 20, and 30 tons per acre tended to increase yields but not significantly.

Title: THE ROLE OF FUSARIUM SPP. AS CROWN AND ROOT PATHOGENS OF FORAGE LEGUMES

Leader: F. L. Lukezic

Work with autoclaved and chemically sterilized soil versus nontreated soil has shown that the normal soil microbial population has an influence on the pathogenicity of organisms being tested. When Fusarium tricinctum was inoculated into treated and nontreated soil, alfalfa roots grown in the nontreated soil were reduced in dry weight by one third. This observation led to investigations which have shown interactions between F. tricinctum, Rhizoctonia spp. and a bacterium isolated from diseased alfalfa roots. In all cases the disease was more severe when the mixture of microorganisms were used than when a pure culture of one was used.

Analyses of enzyme production by pathogenic and nonpathogenic isolates of Fusarium from alfalfa roots have not shown a correlation in the enzymes detected at this time and virulence.

Title: A STUDY OF THE EFFECT OF RATION COMPONENTS ON THE METABOLISM
OF RUMEN MICROORGANISMS

Leader: T. V. Hershberger

A technique was developed to study the various factors that affect the rate of carbohydrate digestion in vitro by rumen microorganisms. The factors investigated were substrate concentration (3 to 60%), carbohydrate source (alphacel, alfalfa hay and corn starch), hay to starch ratio (1:1 to 1:30), and nitrogen concentration (5 to 920 mg nitrogen per 100 ml fermentation medium). In all of these trials, the pH was adjusted manually to 6.95 every one-half hour for 24 hours. In 5 additional trials the pH was automatically maintained between 6.80 and 6.95 with a pH stat.

The maximum rate of carbohydrate digestion--22 grams per 100 ml fermentation medium per 24 hours--was obtained under the following conditions: 48% substrate concentration, one to one ratio of alfalfa hay to corn starch, 820 mg nitrogen per 100 ml fermentation medium, and automatic pH control between 6.80 and 6.95.

These in vitro fermentation rate studies may lead to modified feeding recommendations and greater production efficiencies in ruminants.

RHODE ISLAND

Title: FORAGE CROP ESTABLISHMENT STUDIES

Leaders: R. C. Wakefield and R. T. Leonard

During the 1965 and 1966 growing seasons two separate weed control experiments were conducted to study the effect of time of seeding on the efficiency of several herbicides used in establishing an alfalfa-brome grass mixture. In 1965, the incorporation of either EPIC or Trifluralin into the soil at the time of seeding on May 13 and June 3 resulted in significant control of grass-type weeds and excellent alfalfa establishment. However, both chemicals caused injury and retarded alfalfa establishment on the June 24 seeding date. Applications of these herbicides 3 and 6 weeks prior to seeding in late June were not effective in controlling grass-type weeds. However, yields of brome grass, one year after establishment, were significantly higher than the check when both chemicals were applied six weeks prior to seeding. These herbicides had little effect at any date on broadleaved weed yields although populations were reduced.

Dalapon plus 2,4-DB was not particularly effective in controlling broadleaved or grass-type weeds at any date in the 1965 tests. Heavy weed populations and drought conditions undoubtedly affected results.

In the 1966 test, the effectiveness of 2,4-DB or bromoxynil was excellent at both the first or fourth true leaf stage of treatment with one exception. Broadleaved weed control at the fourth true leaf stage was significantly better than that in the first true leaf stage at the July 12 seeding date due to slow germination of broadleaved weeds. Application of bromoxynil when the temperatures were high resulted in some permanent alfalfa injury, but under normal circumstances only minor leaf scorching occurred. In general, both 2,4-DB and bromoxynil afforded excellent broadleaf weed control in the 1966 test. However, alfalfa establishment was retarded by suboptimum rainfall and secondary weed invasions. Corn spurry following the May 16 seeding and purslane following the June 15 seeding provided serious competition to alfalfa seedling development when primary weed growth was controlled.

VERMONT

Title: RELATION OF SOIL FERTILITY TO CROP ESTABLISHMENT AND PRODUCTIVITY

Leaders: J. L. McIntosh, K. E. Varney, and R. C. Brown

Corn plots established on Panton clay soil in West Addison, Vermont in 1965 were reestablished in 1966 in order to study the chemical and physical effects of manure on soils of this type over a period of five years, and to determine the amounts of nitrogen that must be applied in order to obtain maximum yields of corn. In contrast to 1965, the weather in 1966 was ideal for corn growth. Indications that nitrogen additions to the soil depressed the rate of corn growth were evident again this year. Increasing rates of manure not only made the corn plants grow better but gave significant increases in yields of silage and grain. No definite cause has been determined for these phenomena; however, results have been duplicated in growth chamber studies and hopefully an explanation will be forthcoming. Whatever the cause, these studies have shown most conclusively that manure has value to crops independent of its nutrient content. So far no significant response to nitrogen fertilization has been observed. Normally, annual applications of 200 pounds of nitrogen per acre are recommended for continuous corn.

These results indicate that Vermont soils (at least some Panton clays) may contain considerable quantities of available nitrogen and that research should develop an effective test that can be used routinely for

estimating available nitrogen in soils. Quick tests for nitrogen have been developed in some states, but none have been very satisfactory. A test showing that no nitrogen was needed for the plot area would have resulted in a saving of \$60 per acre (200 lb N x \$0.15 per lb x 2 years) over two cropping seasons. The economic value of research in this area is obvious.

Alfalfa plots established in 1962 to correlate soil tests with crop yields were terminated this year. Data collected over 5 years have served as the basis for correlating new soil testing procedures developed in Vermont. Trefoil plots established to study the effects of different nutrient elements on trefoil seed yields did not produce seed again this year. It appears that climatic factors play the most important part in seed formation and set and that higher levels of fertility have little effect on seed yields under adverse weather conditions.

Title: NITROGEN FERTILIZATION OF BROMEGRASS

Leader: K. E. Varney

Six years ago a study of nitrogen fertilization was started on a mature stand of brome grass growing on Nellis silt loam. A two-cut system was followed. The average date of the first cut was June 23 and the second cut September 30. Late fall nitrogen was applied about October 25, early spring application about April 20, and applications after the first harvest on June 25. Potash was applied 3 times a year in split applications, 60 pounds each in late fall, early spring, and after the first cutting, a total of 180 pounds of K_2O . Each fall 100 pounds of P_2O_5 was applied.

The 5-year average of the season's total production are shown in Table 1.

Table 1. Season's total yield of brome grass (5-year average).

Pounds of N applied			Dry matter tons/acre
Late fall	Early spring	After 1st cut	
50	0	100	5.20 a
100	0	50	5.02 ab
50	50	50	4.98 abc
0	100	50	4.94 bc
0	50	100	4.92 bc
100	50	0	4.78 cd
50	100	0	4.65 d

Yields followed by the same letter in Table 1 are not significantly different according to Duncan's Multiple Range Test.

There appeared to be a relationship between rainfall falling prior to first cut and the season's yield but not between the total seasons' rainfall and the yield (see Table 2).

Table 2. Seasons' total yield of bromegrass and rainfall.

Year	Ton/A	Rainfall (inches)	
		4/1-6/23	4/1-9/30
1964	6.28	8.1	17.7
1965	4.85	6.4	19.7
1963	4.76	6.3	15.3
1966	4.47	5.9	15.8
1962	4.42	5.2	20.4

Title: FORAGE CROP INSECTS, THEIR RELATIVE IMPORTANCE AND CONTROL

Leaders: G. B. MacCollom and B. L. Parker

Cooperative USDA parasite releases of Microctonus aethiops, Bathyplectes curculionis, and Tetrastichus incertus were made during the month of June in Addison and Chittenden counties for biological control of the alfalfa weevil, Hypera postica Gyll. (1965 Annual Report, p. 65). Continued surveys for alfalfa weevil showed the presence of this insect in every county of the state, with populations well above the injury threshold in the southern half of the state.

An evaluation of label-approved insecticides for alfalfa weevil showed that none of the materials displayed sufficient residual properties to give satisfactory control.

Studies on insects affecting birdsfoot trefoil seed production were continued and data were collected for the compilation of disappearance curves on toxaphene at 1.5 lb/act/acre, endrin at 0.2 lb/act/acre and dalapon at 3 lb/act/acre.

WEST VIRGINIA

Title: ALFALFA BREEDING AND GENETICS

Leader: Valentin Ulrich

Serological and electrophoretic investigations of seed antigens were continued (see 1964 Annual Report, p. 64). Studies were also initiated to investigate the inheritance of antigenic differences.

Title: LEGUME ESTABLISHMENT STUDIES

Leader: P. R. Henderlong

Field and greenhouse studies have been initiated on the establishment of alfalfa, birdsfoot trefoil, and crownvetch. Seeding date, seeding rate, companion crops, fertilizer rate, seedbed preparation, and seeding depth are being evaluated.

Title: BIOCHEMICAL STUDIES ON COLD RESISTANCE OF ALFALFA

Leader: G. A. Jung

Studies were undertaken to examine the association between the cold hardiness and nitrogen metabolism of plants of two alfalfa varieties. The genetically hardy variety was found to contain greater quantities of water-soluble TCA-precipitated proteins and nucleic acids than the less-hardy variety during the development and maintenance of cold hardiness. Moreover, the relationships between each of these nitrogenous constituents and cold hardiness were closer for the hardy variety than for the less-hardy variety. Furthermore, seasonal trends for cold hardiness, and content of these constituents were markedly different for the two varieties. In response to changing environmental conditions in the fall, varietal differences were first noted for DNA content, then RNA content, and lastly in the water-soluble TCA-precipitated protein content as well as in cold hardiness of the plants.

Title: THE EFFECTIVE USE OF BLUEGRASS-WHITE CLOVER PASTURES

Leaders: G. C. Anderson, P. R. Henderlong, G. E. Toben, and L. P. Stevens

Thirty-six yearling steers were randomly assigned to 12 groups of 3. Six groups grazed the north-facing slope, while the other six groups grazed the south-facing slope. The hill pastures were supplemented with bottom-land pastures of either Ky-31 fescue, orchardgrass, or bluegrass (aftermath growth). The spring growth of each of these three pastures had been harvested for hay. The hay yields were as follows: Ky-31 fescue, 3043 lb/acre; orchardgrass, 2880 lb/acre; and bluegrass, 2435 lb/acre (calculated on 15% moisture basis). A total of 125 days of grazing was obtained from each pasture unit, 53 days from the hill pastures and 72 days from the bottom-land pastures (hill pastures = 1.4 acres, bottom land = 2.1 acres). Total gains on the south-facing slope were 73% higher than on the north-facing slope. The major reason for the large difference in gains on the two slopes has been attributed to a combination of alfalfa weevil damage and frost damage to the white clover, especially on the north-facing slopes.

One site was selected on each of the two exposures for microclimate measurements. Data are being obtained on soil temperature (surface, 2 inches, and 6 inches), soil moisture (2 inches and 6 inches) and light intensity.

Title: RATE AND TIME OF APPLICATION OF POTASSIUM FOR ALFALFA

Leader: R. F. Keefer

Adverse weather at the beginning of this year prevented adequate treatment for control of alfalfa weevil at Pt. Pleasant and consequently crop damage for the first cutting was so erratic over the plots it was decided to remove the crop without taking any samples. Dry weather throughout the summer at all locations caused less yield than anticipated.

Chemical assays on plant samples for 1964, 1965 (the only years with complete samples and yield data) have been completed and partial statistical analysis shows the following:

For differences due to rate of application of K, the lb K and % K were generally increased with increasing rates of K applied, all cuts, all years. The % Ca showed a decrease with increasing rates of K applied but the significance varied between locations and for different years. The % P showed nonsignificant differences except that at one location there was a decrease with increasing rates of applied K.

For differences due to time of application of K the trend seems to be that the % Ca is highest when K was applied after the second cutting and lowest with K applications split between late fall and after the first cutting. The % K was generally highest when the K was applied in early spring or split between early spring and after the second cut. The lowest % K was found when the K was applied after the second cutting only. The largest amount of K was generally removed following early spring or after first cutting applications; the lowest amount was removed when the K was applied in the fall or split between the fall and the first cutting. The largest amount of P was generally removed following early spring application of K; the least amount was usually removed following an application of K split between late fall and after the first cut.

Title: THE CONTROL OF WEEDS FOR PASTURE AND FORAGE PRODUCTION

Leaders: Collins Veatch and G. C. Anderson

The Experiment Station, the Soil Conservation Service, and the Extension Service cooperated in applying brush killer (2,4-D and 2,4,5-T) to about 515 acres by helicopter. Detailed descriptions and photographs were taken of 1/1000 acre check plots before and after spraying. Spray was applied late in June. July and August were dry. The effectiveness will be evaluated in the spring of 1967. Brush killer and Tordon were also applied with mist blowers and back-pack sprayers.

Eptam and Treflan incorporated at rates of 3 lb/acre, just before seeding alfalfa gave good weed control.

Title: ALFALFA WEEVIL CONTROL

Leader: C. K. Dorsey

A two-year experiment in alfalfa weevil control, using ground equipment to apply concentrate sprays, has been completed. A commercial sprayer (Econo-Mist) and a "homemade" air-syphon type sprayer were used to apply the concentrate sprays. Both kinds produced effective control results. Laboratory studies proved that the insecticides are more effective when applied without water in killing alfalfa weevil adults.

Studies are being conducted to learn more about the aestivation and hibernation habits of the weevil so that ultimately a completely integrated program of control of forage crop insects can be effected. Mechanical methods (LP gas flaming) have proved to be important adjuncts in this relation.

NEW YORK (Cont.)

Title: LEGUME GRASS YIELD RESPONSE TO SURFACE DRAINAGE ON PANTON SILT LOAM AT TWO FERTILITY LEVELS

Leaders: P. J. Zwerman and R. F. Lucey

There are approximately 500,000 acres of poorly drained or "wet" clay soils in a six-county area of Northern New York. Presently all of these are in crop land or pasture. A range of surface drainage practices are in use in attempts to drain these soils. Two such practices, "bedding" and "land smoothing," were partially tested from 1962 to the present on the Amyot farm in Jefferson County. Limited field tests will be continued through 1968 at that location.

Legumes were seeded in 1962 and legume-grass mixtures in 1964. For the first seeding, four years of data are available; for the second, two years are available. Although legume-grass mixtures were seeded in 1962, the grasses did not germinate and only legumes were harvested for the four-year period. The 1964 seeded mixture did result in both legume and grass germination. Fertilization in both years consisted of 300 lb of 10-20-10 at planting time and 200 lb of 0-20-20 after the first cut. A two-cut system was utilized.

The various surface drainage practices consisted of non-bedded, partially smoothed, and bedded. The non-bedded represented the very irregular surface of the field as farmed by the farmer. Partial smoothing consisted of twice over with a land leveler plus a furrow outlet at the lowest corner of the block. Bedding was carried out by building "beds" 80' wide and 20" high at the center. The "upper bed" contained double top soil. The "lower bed" contained little or no top soil. Across a bed the sequence was approximately 20' lower, 40' upper, and 20' lower. Thus the yield for "bedding" should be made up of approximately 50% upper and 50% lower. Because of herbicide residue, wetness, and other causes there was a seeding failure in the lower half of the lower bed. Therefore, harvests were confined to the upper half of the lower portion of the bed. Under conservatively calculated bedding yields, calculations assumed conditions as found in the field. Under liberal calculations it was assumed that all of the lower bed would produce at as high a yield as that portion which had produced a crop. No consideration was given for the nonproducing lower ditch area. A "third cut" was not taken, but this would normally exceed the "second cut". Weed and grass contents as well as percent cover were estimated before each cut. A detailed analysis involving these factors is not presented here.

It is concluded that without surface drainage economic legume stands disappeared during the first year. Harvests were less than 1.5 tons per acre, and were two thirds weeds. There was no fertilizer response.

Partial smoothing resulted in a relatively weed-free yield of over 2.0 tons. Fertilizer response was 0.6 ton on the average. This equalled the yields from "conservatively calculated" bedded areas. Alfalfa-birdsfoot-grass mixtures tended to give the highest yields under all conditions.

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