THIRTY-FIRST ANNUAL REPORT

of

Forage Research

in the

Northeastern United States

1967

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1967

Thirty-First Annual Report

of

Forage Research

in the

Northeastern United States

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

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

and

The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

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Copies of this report were sent to all organizations involved in the forage research program of the 12 Northeastern States, to all investigators in the Northeast Region and to some institutions outside the Region where grassland research is carried on.

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The editor wishes to acknowledge the valuable contributions of Mrs. Lois L. Smith and Mrs. Amina M. Birkenmayer of the Laboratory staff in the many operations necessary for the preparation of this Report.

TO THE COLLABORATORS:

R. B. Alderfer	- New Jersey	B. W. Henderson, Jr.	- Rhode Island
C. S. Brown	- Maine	C. C. Lowe	- New York
G. L. Byers	- New Hampshire	W. H. Mitchell	- Delaware
N. A. Clark	- Maryland	G. G. Pohlman	- West Virginia
R. W. Cleveland	- Pennsylvania	W. W. Washko	- Connecticut
W. G. Colby	- Massachusetts	G. M. Wood	- Vermont

H. R. Fortmann - Representative of Northeastern Directors

I submit this Report, the thirty-first of the series which has been issued annually by the Pasture Research Laboratory. It is intended for the use of personnel engaged in forage research in the Northeastern United States. It contains brief reports of research projects carried on at the State Experiment Stations and at the Pasture Laboratory and the reports, some condensed, of seven Regional Technical Committees. Thanks are due to you, to the Chairmen of the Technical Committees, and to others who collected and edited these reports. Thanks are especially due to each individual who found time, in the midst of making many other reports, to write one more for this edition.

This letter to you will serve also as an introduction to the Report. The readers will note that some changes have been made in the format. At the meeting of the Collaborators at University Park, Pa. in October 1966, it was decided that the question of the continuance of this Annual Report be considered by an ad hoc committee. This committee, composed of R. B. Alderfer, C. S. Brown, H. R. Fortmann, C. C. Lowe, G. G. Pohlman, J. L. Starling, and J. T. Sullivan, prepared recommendations that the Annual Report be continued with revisions. The report of this committee was approved at the Collaborators meeting at University Park in June 1967. This present Report carries out the recommendations, as approved.

The recommendations were intended to update the Report and to pinpoint the responsibilities of preparing it. The Report will continue to be prepared at the Pasture Laboratory with the director of the Laboratory as editor. Each Collaborator will continue to collect and edit the contributions from his station and the editor will have the responsibility of organizing the Report and will have the authority to make alterations if necessary. The format will be designed to emphasize the regional aspects of research. This will be implemented in a number of ways, as follows: (1) The Report contains in its title the term "Forage Research" rather than "Pasture Research," reflecting the changed emphasis on utilization, though the name of the Laboratory will continue to be Pasture Research Laboratory. (2) A list of current investigators in forage research of the whole region replaces the list which contained those of the Laboratory only. (3) The individual contributions are placed in an order reflecting subject matter rather than place of origin. (4) This number contains three short invitational articles which are directed to the understanding of all forage

workers rather than to specialists. (5) The introduction is available for the inclusion of any news items of the region. (6) The list of publications by personnel in the region will be limited to research publications and theses.

Several changes have occurred among personnel. Dr. H. R. Fortmann who has been the representative of the Station Directors of the Northeastern Region to the Laboratory has accepted a newly created post, Regional Coordinator of the Northeastern Association of Agricultural Experiment Station Directors; as representative to the Laboratory he will be succeeded in the coming year by Dr. M. A. Farrell, Director of the Pennsylvania Station. The officer-in-charge of the Laboratory has had a change of title to Director, a position which has been vacant since 1957. Already mentioned was the appointment early in 1967 of Dr. W. W. Washko as Collaborator from Connecticut. Dr. W. F. Millier of New York was on leave of absence and in his place Dr. C. C. Lowe is now Collaborator from New York. The only change in the Laboratory staff was the appointment of Mr. C. C. Duke, a graduate of The Pennsylvania State University as assistant botanist, following the resignation of Mrs. Carol Shores.

The conference of the Collaborators which was held in October 1966, and reported on last year, was continued by a one-day session in June 1967 at University Park to complete unfinished business. Invited to attend were representatives of five Northeastern Regional Technical Committees who presented the research needs of their respective disciplines and recommended research activities for the next 10 years. These proposals were accepted by C. S. Brown, Chairman of the Collaborators, for the purpose of establishing priorities. The research needs were discussed further at the joint meeting of four regional committees at New York in January 1968.

The architectural firm of Jack Risheberger and Associates of State College has been employed to draw plans for the enlargement of the Pasture Laboratory building. The plans which are nearly complete will call for the addition of a wing, 30' x 79', at the rear of the present building, that will join at 4 floors to the present building and at the ground floor to the headhouse. The overall increase in floor space will be about 80 per cent. There will be 10 additional offices and 8 laboratory rooms. The basement of the addition will consist of one large room designed for growth chambers. It is hoped that construction will be carried out during 1968.

The Laboratory has had constructed a building, 20' x 80', at the new Agricultural Research Center at Rock Springs. It will be used to store farm equipment and will contain, when installed, facilities for drying forage samples from the field plots. Up to now, all such samples had been brought to the main laboratory building for drying.

J. T. Sullivan, Director
U. S. Regional Pasture Research Laboratory

Roster of Research Workers in the Northeastern United States

Alderfer, R. B.	Soil-Plant-Water Relations	New Jersey
Allinson, D. W.	Forage Management	Connecticut
Anderson, G. C.	Animal Nutrition	West Virginia
Anderson, R. E.	Genetics and Breeding	Cornell
Apgar, W.	Animal Nutrition	Maine
Bartlett, R. J.	Soil Science	Vermont
Baumgardt, B. R.	Animal Nutrition	Pennsylvania
Benoit, G.	Soil Physics	Vermont
Berg, C. C.	Genetics (Grasses)	Pasture Laboratory
Bloom, J. R.	Nematode Control	Pennsylvania
Bratzler, J. W.	Animal Nutrition	Pennsylvania
Braverman, S. W.	Plant Pathology	Geneva
Brown, C. S.	Forage Management	Maine
Byers, G. L.	Agricultural Engineering	New Hampshire
Campbell, J. K.	Agricultural Engineering	Cornell
Clark, N. A.	Forage Management	Maryland
Cleveland, R. W.	Genetics and Breeding	Pennsylvania
Colby, W. G.	Forage Management	Massachusetts
Colovos, N. F.	Animal Nutrition	New Hampshire
Connell, W. A.	Insect and Mite Control	Delaware
Crittenden, W. H.	Legume Diseases	Delaware
Decker, A. M.	Forage Management	Maryland
Devine, T. E.	Genetics and Breeding	Cornell
Dickey, H. C.	Forage Preservation	Maine
Dolan, D. D.	Plant Introduction	Geneva
Dorsey, C. K.	Entomology	West Virginia
Drake, Mack	Forage Management	Massachusetts
Duke, C. C.	Cytology	Pasture Laboratory
Duke, W. B.	Weed Control	Cornell
Dunn, G. M.	Genetics	New Hampshire
Elgin, J. H. Jr.	Genetics (Alfalfa)	Pasture Laboratory
Elliott, E. S.	Root Diseases	West Virginia
Etgen, W. M.	Animal Physiology	Rhode Island
Evans, J. L.	Nutritional Value	New Jersey
Fenner, H.	Animal Nutrition	Massachusetts
Flannery, R. L.	Soil Fertility	New Jersey
Fortmann, H. R.	Representing N.E. Directors	Pennsylvania

Gershoy, A.	Genetics	Vermont
Gross, C. F.	Soil Fertility	Pasture Laboratory
Gyrisco, G. G.	Entomology	Cornell
Haenlein, G.F.W.	Nutritive Evaluation	Delaware
Halisky, P. M.	Plant Pathology	New Jersey
Hemken, R. W.	Dairy Science	Maryland
Henderlong, P. R.	Forage Management	West Virginia
Henderson, R. W. Jr.	Animal Nutrition	Rhode Island
Hershberger, T. V.	Animal Nutrition	Pennsylvania
Hill, R. R. Jr.	Genetics (Alfalfa)	Pasture Laboratory
Holter, J. B.	Animal Nutrition	New Hampshire
Howard, F. L.	Pathology, Entomology	Rhode Island
Hower, A. A. Jr.	Forage Insects	Pennsylvania
Ilnicki, R. D.	Weed Control	New Jersey
Jung, G. A.	Plant Physiology	West Virginia
Kardos, L. T.	Soil Physics	Pennsylvania
Keefer, R. F.	Soil Fertility	West Virginia
Kesler, E. M.	Dairy Science	Pennsylvania
Kjelgaard, W. L.	Agricultural Engineering	Pennsylvania
Leath, K. T.	Pathology (Legumes)	Pasture Laboratory
Linscott, D. L.	Weed Control	Cornell
Lowe, C. C.	Genetics and Breeding	Cornell
Lucey, R. F.	Forage Management	Cornell
Lukezic, F. L.	Forage Pathology	Pennsylvania
MacCollom, G. B.	Entomology	Vermont
MacDonald, H. A.	Forage Management	Cornell
Marriott, L. F.	Soil Fertility	Pennsylvania
Martinson, C. A.	Physiology of Root Diseases	Cornell
McIntosh, J. L.	Soil Science	Vermont
McKee, G. W.	Ecology, Physiology	Pennsylvania
Millier, W. F.	Agricultural Engineering	Cornell
Mitchell, J. R.	Forage Management	New Hampshire
Mitchell, W. H.	Forage Management	Delaware
Morgan, O. D.	Plant Pathology	Maryland
Murphy, R. P.	Genetics and Breeding	Cornell
Neal, J. W.	Entomology	Maryland
Newton, R. C.	Forage Insects	Pasture Laboratory
Pardee, W. D.	Forage Management	Cornell
Parochetti, J. V.	Weed Control	Maryland
Peters, R. A.	Weed Investigations	Connecticut
Plummer, B. E.	Biochemistry, Forage Quality	Maine
Pohlman, G. G	Soil Fertility	West Virginia
Poulton, B. R.	Forage Utilization	Maine

Race, S. R. Jr.	Forage Insects	New Jersey
Ramage, C. H.	Production, Utilization	New Jersey
Reid, J. T.	Animal Nutrition	Cornell
Reid, R. L.	Animal Nutrition	West Virginia
Riker, J. T. III	Animal Husbandry	New Hampshire
Risius, M. L.	Genetics and Breeding	Pennsylvania
Robinson, R. R.	Soil Science	Pasture Laboratory
Routley, D. G.	Plant Chemistry	New Hampshire
Rowe, R. J.	Engineering, Harvesting	Maine
Salomon, M.	Agricultural Chemistry	Rhode Island
Schillinger, J. A.	Plant Breeding	Maryland
Seaney, R. R.	Forage Management	Cornell
Shaw, F. R.	Forage Insects, Control	Massachusetts
Simpson, G. W.	Forage Insects	Maine
Singley, M. E.	Engineering, Utilization	New Jersey
Smith, A. M.	Animal Nutrition	Vermont
Sprague, M. A.	Management, Preservation	New Jersey
Sprague, V. G.	Microclimatology	Pasture Laboratory
Sproston, T.	Plant Pathology	Vermont
Starling, J. L.	Genetics and Breeding	Pennsylvania
Sullivan, J. T.	Plant Chemistry	Pasture Laboratory
Toben, G. E.	Agricultural Economics	West Virginia
Ulrich, V.	Plant Breeding	West Virginia
VanderNoot, G. W.	Forage Utilization	New Jersey
Vandersall, J. H.	Dairy Science	Maryland
Varney, K. E.	Forage Management	Vermont
Veatch, C.	Weed Control	West Virginia
Wakefield, R. C.	Forage Management	Rhode Island
Washko, J. B.	Forage Management	Pennsylvania
Washko, W. W.	Forage Management	Connecticut
Welch, J. G.	Nutritional Value	New Jersey
Wiggans, S. C.	Plant Physiology	Vermont
Wood, G. M.	Forage Management	Vermont
Wright, M. J.	Forage Management	Cornell
Yendol, W. G.	Non-pesticide Insect Control	Pennsylvania
Zeiders, K. E.	Plant Pathology	Pasture Laboratory
Zwerman, P. J.	Soil Conservation	Cornell

INVITATIONAL PAPER

Factors Associated with Estrogenicity of Alfalfa

C. H. Hanson[1]

Estrogenic activity has been noted in more than 50 species in 25 families of plants. It was reported in roots, tubers, stems, leaves, flowers, and seeds. However, in most cases, relatively low potency was found and little significance was attached to it.

Although estrogens had been reported in forage crops, interest in them did not develop until an outbreak of sterility in ewes in Australia was attributed to subterranean clover (Trifolium subterraneum) with estrogenic activity. Australian workers showed that subterranean clover contained genistein, formononetin, biochanin A, and daidzein, which were isoflavones with estrogenic activity. Workers at the Western Regional Research Laboratory of the U. S. Department of Agriculture isolated and described the estrogen coumestrol in alfalfa (Medicago sativa) and ladino clover (Trifolium repens).

Coumestrol has a coumarin-like structure. It is about 30 to 40 times more potent than isoflavone estrogens in mouse uterine-weight assays. Coumestrol, administered orally or subcutaneously, produces an increase in uterine weight in immature or ovariectomized mice. It is about 30 times more potent than genistein, but considerably less active than the natural animal estrogens or synthetic stilbestrol. Coumestrol content of estrogenic, dehydrated alfalfa samples accounted for 90 percent or more of the estrogenic activity. The four isoflavones mentioned accounted for most of the remaining activity.

The Crops Research Division, including the U. S. Regional Pasture Research Laboratory, of the U. S. Department of Agriculture conducted a biometrical study to characterize variation in coumestrol content of alfalfa. This study was in cooperation with the State Agricultural Experiment Stations of California, Iowa, Kansas, Nebraska, Pennsylvania, North Carolina, South Dakota, and Utah, and the Western Regional Research Laboratory. The results showed that more than 99 percent of the variation observed in coumestrol content of five alfalfa varieties grown over a 2-year period at 7 locations could be attributed to environmental factors. Also, defoliation was the only variable studied which was closely correlated with coumestrol content. These clues, together with low coumestrol contents in Utah and California, led to a discovery linking coumestrol synthesis with foliar diseases.

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[1]Research Agronomist, Crops Research Division, Agricultural Research Service, U. S. Department of Agriculture, Beltsville, Md.

Healthy alfalfa was infected with each of the following foliar pathogens: Phoma herbarum var. medicaginis, Pseudopeziza medicaginis, Leptosphaerulina briosiana, and Stemphylium botryosum. In each case, coumestrol content increased as a result of infection. Coumestrol seldom occurred at levels of more than 2 ppm in healthy alfalfa. In one study, disease-infected forage contained as much as 600-800 ppm. Most of the coumestrol was found in or near lesions. Foliar diseases also caused the accumulation of flavones and other coumestans in alfalfa. Infestation with certain insects also increased coumestrol content but to a much less degree than did foliar diseases.

The effects of natural plant estrogens, as coumestrol, on animal performance are not fully understood. There is experimental evidence that the natural plant estrogens have some of the same effects as stilbestrol which reduces fertility in animals and by limiting reproduction causes a significant economic loss. On the other hand, there is some evidence that the naturally occurring estrogens may promote the growth of lambs and steers and the fattening of poultry. Therefore, estrogenicity causes alfalfa quality to take on added significance. Alfalfa that is poor in quality because of infection with foliar diseases is likely to be estrogenic. Conversely, the estrogenic activity of good quality forage, free of foliar diseases, is likely to be low.

Understanding the coumestrol-disease relationship in alfalfa will aid farmers in obtaining the greatest returns from growing and feeding alfalfa. A farmer will know that moist growing conditions, such as those that occur in parts of the growing season in the eastern United States, favor disease development. This, in turn, will increase the amount of coumestrol in alfalfa forage. A long interval between cuttings favors diseases and coumestrol buildup. This is especially important where forage from nonirrigated fields is chopped and fed green because intervals between cuttings may vary considerably. Unless surplus forage can be made into silage or hay, increased production resulting from abundant rainfall tends to delay removal of the next crop and thus increase the incidence of foliar diseases and coumestrol.

It has been demonstrated that when alfalfa is bred for disease resistance, one of lower coumestrol content is also obtained. Breeding, therefore, appears to be the best method of controlling coumestrol content. One cannot rule out the existence in alfalfa of inherent factors for coumestrol per se. This was indicated in a Purdue study. However, genetic factors were small as compared to those associated with foliar diseases. Disease resistance is generally associated with higher protein and other constituents and thus affects quality as well as yield. Thus breeding to control foliar diseases and coumestrol can be expected to be especially fruitful in the Northeastern States where foliar diseases are common. Crop management can be used to a limited extent to control the coumestrol content of susceptible varieties.

Work on M. littoralis (barrel medic) in cooperation with the South Dakota Agricultural Experiment Station suggested another kind of mechanism associated with accumulation of coumestrol in that species. Coumestrol content

increased with formation of a nonpathogenic form of spotting and with age of the leaves. Young leaves without spots had no measurable coumestrol. Older leaves with numerous spots contained as much as 2000 ppm coumestrol. The contrast between M. littoralis and M. sativa indicates that it is unwise at this time to make a general statement as to the cause of estrogenicity in other species. While the factors associated with accumulation of coumestrol in M. sativa and M. littoralis appear quite different, spotting is common to both. This observation may have some significance in developing a better understanding of the biosynthesis of coumestrol in Medicago.

INVITATIONAL PAPER

How Insects Affect Forage Production

R. C. Newton[1]

Some 150 different species of insects feed on forage plants. About 15 percent of these are of annual economic importance while others are minor pests that occur periodically in lesser outbreaks. Forage insects show a great diversity in form, development, habits, fecundity and capacity to damage plants. Some have 1 generation a year while others have 3 or more. Some are general feeders, attacking a wide selection of host plants, while others are specific feeders restricted to one or a few species of plants. Insects possess 2 kinds of mouth parts--those with biting mandibles capable of cutting or chewing leaves and roots, or tunneling within these tissues; and those with sucking mouth parts capable of piercing cells and tissues and injecting saliva and extracting plant juices. The ways in which the alfalfa weevil, Hypera postica (Gyll.), clover root curculio, Sitona hispidula (Fab.), meadow spittlebug, Philaenus spumarius (Linn.), and potato leafhopper, Empoasca fabae (Harris), injure plants are described in this paper. The first two insects have biting mouth parts and crush and eat plant tissue. The last two injure plants by sucking out their juices.

Most piercing and sucking insects that attack plants have their mandibles and maxillae parts modified into 4 long, needle-like stylets encased in a jointed beak. The inner surfaces of the stylets are grooved so that when compressed they slide against each other and likewise form 2 canals, each connected with a head pump. Through one canal saliva is carried into the plant while through the other partly digested plant fluids are sucked

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[1]Research Entomologist, U. S. Regional Pasture Research Laboratory, University Park, Pa.

up by the insect. The sliding stylets are inserted into the plant by pushing first one, then the other forward. Some species push their stylets through plant cells; others guide them between cells, while still others may employ both methods. Once the stylets are properly placed within plant tissue and as the insect feeds, a sheath material apparently derived largely from the insect's salivary glands, is gradually formed around them. The sheath material takes the form of a tube open at both ends. It remains in the plant tissue whenever the insect withdraws its stylets. In addition to the injury induced by eating plant tissue or sucking juices, some forage insects have either a knife-like, or a saw-like ovipositor designed to cut a slit in stems or leaf veins in which their eggs are placed. The alfalfa weevil lacks such a cutting ovipositor. It chews a hole in the stem, then places its soft ovipositor in the hole and fills it with a cluster of eggs. Wounds produced by both feeding and egg laying open the way for invasion by several disease organisms. Then several of the forage insects actually transmit plant diseases, either externally or internally and inoculate host plants as they feed. A number of viruses are spread in this way. In addition to these injuries, some aphids and leafhoppers deposit droplets of a sticky honeydew material over leaf surfaces which supports the growth of a black fungus. The immature spittlebugs encase themselves in a protective froth-like spittle that may, when sufficiently plentiful, interfere with the curing of hay. The net result of insect activity is a marked reduction in both quality and quantity of the forage produced.

The alfalfa weevil has one generation a year. Adults lay their eggs in both dead and living plant stems in the fall and early spring. A female may lay from 100 to 1,000 eggs and averages about 560 eggs. On hatching, small larvae crawl up the stems and eat into the soft tissue within the top buds. A few days later they emerge to attack the older open leaves causing a ragged appearance first in the tips and later over the entire plant. Large numbers of larvae are able to consume leaves faster than the plant can produce them, until little but dried leaf veins and stems containing little nutritive value remain. When the first crop is cut many small larvae are killed, but the larger larvae fall to the ground and gather on the emerging second crop buds and shoots to slow or halt an already weakened regrowth. This delay in regrowth continues until the large larvae complete their feeding and cocoon, a period that may be of 1 to 3 weeks duration. New weevils emerge in a matter of days, and when present in sufficient numbers their feeding can extend the injury into the second crop period. In certain areas in the Eastern United States, larvae have persisted in damaging numbers into the third crop, suggesting the occurrence of a possible second generation of the weevil.

The clover root curculio attacks alfalfa, red clover, ladino clover and some grasses. It has one generation a year. Females lay from 30 to 150 eggs, and average about 80 eggs each. These are dropped singly on the soil starting in the fall and continuing through the spring. Hatching occurs in the spring and grubs enter the soil and cut and eat rootlets and nodules. They gouge tap roots as they grow, which in the case of red clover, increases the incidence of Fusarium root rots. Grub populations of from 60 to 80 per square foot are not uncommon in May. Damage goes unnoticed and

is not fully appreciated since it occurs beneath the soil. The combined action of grub injury and root rots reduces top growth and yields, and in the case of red clover, the two in conjunction with a third insect, the clover root borer, Hylastinus obscurus (Marsh.), are largely responsible for terminating the life of stands in the second harvest year.

The meadow spittlebug is a sucking insect having one generation a year. It is a general feeder, infesting many weeds, alfalfa, red clover, ladino clover, and grasses. Nymphs hatch in May from overwintering eggs laid in clusters the previous fall at the base of dry grass, grain, stubble, and old plant stems throughout fields. These gather in spittle masses made by the nymphs on plant stems and leaves. The spittle is a liquid derived from the plant and expelled through the insect's anus while the froth is made by air bubbles brought into the liquid by purposeful movements of the insect's abdomen. In heavily infested fields it is not uncommon for plants to support numerous spittles, each containing from 1 to some 15 nymphs of various sizes. The feeding of small nymphs distorts the expanding leaves of young alfalfa; that of larger nymphs stunt the internodes and causes the terminal growth to rosette, at the same time reducing first crop yields as much as 25 to 50 percent. Numerous masses of spittle can at times wet the hay sufficiently to interfere with curing operations.

Nymphs stop feeding when fully grown. The spittle foam dries and forms a protective chamber from which the adult emerges in June. Adults are able to fly and leave harvested fields to concentrate in uncut legumes and grasses where they feed until killed by cold weather. While adults are not as destructive as nymphs, large numbers can delay regrowth following harvest, and they lower the quality of forage by reducing protein, fat, and moisture content.

The potato leafhopper is a sucking insect having 3 or more generations a year. It overwinters only in the south and is carried north each spring by flight and wind currents, arriving in the Northeastern states from early to mid-May, in time to reproduce to economic numbers and damage second and third crop legumes. It does not attack grasses. Both nymphs and adults cause trifoliolate and top wilting in young alfalfa, while they stunt the growth and discolor leaves of older plants. Some alfalfas turn yellow, while dark green alfalfas turn a reddish color. Stunting is produced when nymphs and adults feed on the rapidly elongating top 5 or 6 internodes. It is possible to arrest a specific top internode by caging a leafhopper on it for 1 to 2 days. The infested internode stops elongating while the adjacent ones continue to do so. Leafhoppers have been observed to produce tumors at feeding sites on stems and leaf veins of certain susceptible alfalfas. Females are more destructive than males, due possibly to differences in feeding, or because females oviposit within stems and leaf veins. In the process of feeding, both immature and adult leafhoppers excrete droplets of liquid on the foliage. They probe the phloem tissue or the xylem vessels when feeding, and the salivary secretions cause nuclear enlargement and hypertrophy in the affected cells. These in turn plug or block the vascular system, causing the color changes in leaves. The wilt, color changes, and stunted growth are accompanied by a reduction of up to 27 percent in yield. The quality of the forage is also

affected as shown by reduced production of protein, ash, calcium, and phosphorus, all of which are important animal nutrients.

Attacks by insects produce a more or less continuous stress in forage crops during their entire growing season. Damage is variable in the different states, due in part to variations in climate, insect distribution, population levels and harvesting practices. Fortunately, many of the forage insects in turn have their own insect parasites and predators, while new parasites are being introduced as they are discovered in foreign countries. Control of most forage insects can be achieved through the use of insecticides recommended by State Experiment Stations, and the U. S. Department of Agriculture.

INVITATIONAL PAPER

The Regional Plant Introduction Station--Its Processing of Forage Legume and Grass Introductions

D. D. Dolan[1]

The Regional Plant Introduction Station at Geneva is directed by the Regional Committee, NE-9. This committee is composed of a representative of each of the 14 cooperating state experiment stations in the Northeastern region, an administrative advisor, who supervises the expenditures and holds the purse strings for the project, and a representative of each cooperating federal agency, namely, the New Crops Research Branch, the Soil Conservation Service, and the U. S. Forest Service. The operating funds are contributed approximately equally by the Regional Research Fund, NE-9, and the New Crops Research Branch. The Station functions as a liason between the aforesaid Branch which introduces the plant introductions from abroad and the cooperating state experiment stations who conduct evaluations on these introductions.

There are three other regional introduction stations--at Ames, Iowa, Experiment, Ga., and Pullman, Wash. To avoid duplication by these stations, each regional station has the responsibility for maintaining introductions of a certain number of crops. The station at Geneva has the main responsibility of growing, evaluating, seed increasing, and maintaining introductions of tall oatgrass, trefoil, Lotus, perennial clovers, as well as many nonforage plants.

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[1]Coordinator, Regional Project NE-9, New York Agricultural Experiment Station, Geneva, N. Y.

The stations were established mainly to handle seed-propagated crops. A very large proportion of the introductions obtained abroad arrive as seeds which are collected during well-planned foreign explorations. Proposals for foreign explorations have a grass-roots origin, that is, they may be offered by agronomists of the region or such proposals may be planned by a subdivision of the New Crops Research Branch named the Division of Exploration and World Plant Resources. The forage legume and grass accessions from foreign countries may have been collected in the wild, from cultivated fields, from an agricultural experiment station, or from a seed store. Those from the last two sources are usually either breeding lines or named cultivars. When the explorers collect a plant or seed they try to document it as completely as possible. Breeding lines and cultivars are usually documented with the foreign cultivar names and one or more of the meritorious characteristics claimed for them. Collections from the wild are labeled with the town or village, the elevation of the terrain, the soil structure, the topography, and general comments on the vegetation.

The station at Geneva is concerned namely with alfalfa, perennial clovers, trefoil, and grasses. Seeds which arrive from abroad are accepted and planted. A new forage planting is set out each year and all are carried into the third growing season. All forage plantings are spaced plantings in rod rows 4 feet apart with plants one foot apart in the rows. Individual crops as red clover are planted only in alternate years. This makes possible larger plantings and greater efficiency in handling. Seeds of all forage legumes and grasses are planted in late winter or early spring (February 15 to March 31) in single rows in seed flats in the greenhouse. At the appropriate time, the seedlings are transplanted to 3-inch pots where they remain while growing in the greenhouse, for 4 to 6 weeks in the cold-frame until they are transplanted to the field at about mid-April.

In the spring before planting the forage area is fertilized by drilling in 10-20-20 fertilizer at the rate of 320 lb per acre. Forage areas in their second and third growing seasons are sidedressed in April with a complete fertilizer (10-20-20) at the rate of 160 lb per acre.

As each growing season progresses, descriptive notes are taken on each forage legume and grass introduction. Shortly after vegetative growth resumes in spring, notes are taken on the percentage of plants that survive the winter. Simultaneously or shortly thereafter, notes are taken on spring growth and spring vigor. This is accomplished using a rating scale 1-9, where 1 indicates the least amount of growth, 9 the most growth, and 5 the medium growth.

At the appropriate time for each introduction, notes are taken on plant habit, vigor, size of plant, crown width, number of stems, and size of stems. Each row is rated according to leaf color into three categories: light green, medium green, and dark green. During the latter half of the growing season, notes are taken on date of bloom, ease of shattering, day of harvest of ripe seed, and any other head or seed characteristic. Throughout the whole growing season, ratings are taken on the degree of

damage by various diseases and insects. When the seed harvest is complete (alfalfa is not seed-increased), usually sometime in September, the plants are mowed and later on (in October) ratings of fall recovery or regrowth are taken. The ripe heads from each rod row are harvested by hand, usually with a hand-shears; placed in a paper bag or a berseem cloth bag, tied, labeled with the row number and the plant introduction number and conveyed to the seed processing building. Before threshing, the field moisture must be artificially removed and this is done by forcing through the bags, circulating hot air at a temperature of 105 to 110°F. So that the drying is uniform, the bags are stirred and rotated from time to time.

Most of the threshing is done either with a small hammer-mill or with an open-head thresher. Frequently for complete threshing, more than one passage through the threshing machine is required. The first cleaning of the threshed seeds is made by passage through a separator or fanning-mill and the second cleaning is done with various types of air-draft machines such as an aspirator or South Dakota seed blower. When the seed lot of each introduction is thoroughly cleaned, it is separated into two components, two-thirds and one-third. Two thirds of the increase seed is placed in a spear-point envelope and placed in long-term storage at 33°F and 30% relative humidity. The remaining one third of each increased seed lot is placed in a smaller metal fold envelope and placed in a temporary storage with the same atmospheric conditions. The temporary storage is open more frequently and from this storage, packets are filled to comply with current requests from cooperators throughout the United States.

In August of each year, the Representatives of NE-9 assemble for a two-day meeting at Geneva. One full day is given to touring the field plots, observing the plant introductions and making note of those that might be of use at the home experiment station. Agronomists are also encouraged to make such visitations, but if such visits are impractical, a cooperator may maintain a file of each of our catalogs of available forage legumes and grass introductions. These are released in alternate years, 1964, 1966, 1968, etc. Each catalog is in tabular form and describes approximately 18 to 20 agronomic traits for each introduction.

We have no objection to agronomists visiting our plantings and selecting individual plants that may be of potential value. For instance, the Soil Conservation workers at Big Flats, N. Y. visit our plantings each season and with a sharp shovel cut out pie-shaped sections of certain forage plants. These clonal propagules are set in the field at Big Flats so that they have sufficient time in the same season to develop roots and become securely anchored before fall dormancy sets in. Each agronomist is also encouraged to peruse the supplement to our annual report entitled, "Promising Forage Legume and Grass Introductions of the Year." In this supplement we reviewed the promising introductions as observed at the Regional Station and also the promising introductions as reported by cooperators in the 14 state agricultural experiment stations. Agronomists are also encouraged to peruse our mimeographed plant introduction memoranda, which are issued from time to time. So far, we have released 146 such memoranda, and each one contains a section on the merits and performance

of forage legume and grass introductions currently being evaluated by cooperators. Someday, we hope to have punched on IBM cards the evaluation data and performance data for each forage crop introduction. If such cards were available, an IBM sorting machine could then be used to select forage introductions having various combinations of traits. For instance, by pushing the proper buttons, the machine would throw out all cards of alfalfa introductions having a combination of good vigor, leafiness, high winter survival, good spring recovery, and relative freedom from disease and insect damage.

RESEARCH IN THE NORTHEASTERN REGION

Section I

Introduction, Genetics, Breeding, Strain Evaluation, etc.

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

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

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

The plantings at the Geneva Station in 1967 consisted of over 800 forage legumes and grasses, of which 600 were carried over from 1966. Descriptive and evaluation notes were recorded on all introductions and the information was distributed to plant breeders in the annual catalog. Some promising introductions are as follows:

Thirteen alfalfa introductions were used in top crosses with commercial varieties by Northrup King and Co., viz., P.I. 199271, 205329, 224944, 222729, 251225, 251561, 258818, 258823, 258825, 258832, 262538-39, and 262544. An introduction from France, P.I. 236605, is fairly hardy, vigorous, leafy, and in a 2-year trial outyielded Vernal at Ottawa. Another from France, P. I. 256004 had a 100% winter survival at Geneva and an 80% survival at Ottawa; it is tall and vigorous with exceptionally long stems and large leaves; its production at Ottawa equaled Vernal.

A screening of red clover revealed that 17 introductions may carry tolerance or resistance to powdery mildew.

A Russian introduction of birdsfoot trefoil (Morshansk, P.I. 258467) was used in the development of the new variety Leo in Quebec.

Sixteen rust-resistant selections of tall oatgrass were given P.I. numbers 323481-96 incl.

A smooth bromegrass from USSR, P.I. 258744, gave a yield comparable to Saratoga, at Ottawa. It is vigorous, leafy, and produces good aftermath.

A perennial ryegrass from Finland named Valinge, P.I. 197270, has excellent winterhardiness and is satisfactory in vigor, leafiness, and other features.

Two tetraploid timothy introductions, P.I. 234445 and 234724, from Western Europe were of interest at the Wisconsin Station. Compared to the ordinary hexaploid timothies, they had low vigor, short height, finer leaves and culms, and small inflorescences, and tended to be semierect rather than erect. Individual plants varied from good resistance to complete susceptibility to stem rust and leaf blight. A clonal line of timothy from USSR, P.I. 258781, was originally selected for leafiness and lateness of bloom with the leaves high on the culms. On June 12, 1967 the plants were 30 in. tall and 16 in. across; they were in full bloom on July 18 and ripe seed was harvested on August 25; they appeared to be drought tolerant.

An introduction of Agrostis tenuis from Italy, P.I. 252045, was included in the self-pollination program in Pennsylvania; it forms spreading clumps with a thick leaf crown and relatively fine leaves.

A reed canarygrass from Sweden, P.I. 235546, outyielded Frontier and Ioreed at both the pasture and hay stages.

Other introductions are described in Supplements to the Annual Report and include species of Trifolium Bromus, Phalaris and Lolium besides those already mentioned.

Title: PROJECT NE-28 - BREEDING OF IMPROVED VARIETIES OF FORAGE SPECIES ADAPTED TO THE NORTHEAST

Leader: W. W. Washko, 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.

Formulation and testing of synthesis procedures, genetic studies, synthesis and evaluation of new varieties and cooperative seed production are integral phases of the present project continued in 1967. Work is in progress at six Northeastern State Experiment Stations and the U. S. Regional Pasture Research Laboratory on a total of seven perennial forage crop species.

Formulation and testing of variety synthesis procedures for perennial forage crops.--Continuing substantial effort is given to methodology for synthesis techniques. Four stations (N.H., N.Y., Pa. and the Pasture Laboratory) are participating in synthesis studies.

Alfalfa.--The inbreeding program with USDA MS-A and MS-B gene pools initiated in 1965 has been continued. Only 49 remain into the S_4 generation from the 200 originally represented. These are weak and planned production of single crosses, double crosses, and synthetics from S_0, S_3, and S_6 generations may be difficult to achieve (Pasture Laboratory).

Timothy.--Extensive studies are in progress on use of single-clone derived lines as parents in synthesis combinations. Predictable changes in plant maturity with consequences to productivity are becoming evident.

Orchardgrass.--Synthetics constituted on basis of wide and local adaptation of parent clone progenies are under comparison at three stations.

Bromegrass.--From third harvest year tests of diallel single crosses, average yields in the Syn 1 exceeded those in the Syn 2 by a highly significant difference, verifying results in the earlier harvest years (N.H.).

Genetic studies--Alfalfa.--An investigation of genetic models and mating designs to permit genetic interpretations of results obtained from crosses was initiated (Pasture Laboratory).

Bromegrass.--Families with albino, rolled leaf, and yellow mutant characters have been established and segregations are being determined. Ratios of normal to albino seedlings in F_2 and F_3 families were found to be highly variable. Relationships of temperature and daylength to expression of the albino trait were studied in growth chambers and, although both factors had a significant effect, no interaction was observed (N.H.).

Crownvetch.--Populations of clones from various sources have been established and their variability is being observed. Counts verify previously reported chromosome numbers (Pa.).

Seed production.--Successful seed production of alfalfa, birdsfoot trefoil, bromegrass, lolium-festuca derivatives, orchardgrass, and timothy was secured in 129 of 190 cage isolations. Sixteen of 17 field isolations were also successful. Unfavorable weather and heavy insect populations in 1967 were detrimental to seed production of some species but seed supplies should be adequate for continuing genetic and synthesis studies.

Evaluation of new synthetic varieties.--The determinations on comparative forage yields between newly synthesized varieties and those in current general use are being conducted at nine locations. These same studies frequently are being concurrently used to evaluate variety synthesis procedures. Thirty-two yield trials provided data in 1967 for the 7 species presently within the project's scope.

USEFULNESS OF FINDINGS:

Over 60% of 1967 Northeastern use of alfalfa seed (3 million lbs.) was for varieties developed in the region and cooperatively evaluated through NE-28. This usage and known performance differences indicate Northeast farmers annually produce an additional 5 to 10 million dollars worth of alfalfa by using these improved Northeastern varieties. Full use of the recently-released Saranac and Iroquois varieties will return even larger benefits. Some use of these varieties is also anticipated outside of the region.

Title: THE BREEDING, GENETICS AND CYTOLOGY OF FORAGE LEGUMES

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

Cytological studies of diploid Medicagos including those of somatic and pachytene chromosome morphology were completed. In either root tips or pollen tubes variability was present in measurements so that several chromosomes were statistically similar. The identification of trisomics via measurement of somatic chromosomes would not be practical. The arm-length ratio was the most consistent character of somatic chromosomes. Pachytene chromosomes were less variable in measurements, and probably more useful for trisomic identification through use of relative length and chromosome arm-length ratios.

The cytogenetics of species hybrids in Trifolium was clarified. Hybrids made at sesquidiploid level (4X pratense x 2X pallidum) were variable in morphology and highly sterile. In hybrid meiosis the most frequent chromosome pairing was that without pratense-pallidum chromosome associations, however many had heterogenetic associations. Breeding red clover by transfer of genes from T. pallidum would be possible if a slight degree of hybrid fertility could be demonstrated.

Embryological examinations of diploid hybrid (2X T. pratense x 2X T. pallidum) showed normal development of embryo up to about 7 days. Subsequent embryo abortion was attributed to abnormal endosperm development.

Production of progenies for use in breeding alfalfa for creeping-rooted habit was accomplished. Field experiments to evaluate alfalfa varieties and breeding materials were carried out.

Title: INBREEDING IN ALFALFA

Leader: R. R. Hill, Jr., Pasture Laboratory

A program of selfing was initiated in a random sample of clones from each of 2 alfalfa populations designated Pool A and Pool B (see 1966 Annual Report, p. 4). Inbred lines obtained are to be used as parents of hybrids and synthetics to determine the effects of inbreeding in parents on hybrid vigor of progenies. S_4 plants from 28 lines of Pool A and 21 of Pool B have been obtained, but S_4 seed production was poor. The S_4 lines are quite weak and early indications are that production of S_5 seed will be as bad or worse than S_4 production. S_3 lines which produced seed were placed in a clonal nursery for future use.

A search for a model which will permit genetic interpretations of responses to inbreeding has been started. Multiple regression with line means as the Y variable and expected frequencies of genotypes of different degrees of heterozygosity as the X variables provide a model in theory, but not in practice. Ample seed of at least 5 generations of selfing in each line would be required, which seems impossible. The regression approach is unbearably complicated when extended to hybrids or synthetics. A more suitable model is being sought.

Title: COMPARISON OF 4 METHODS OF SELECTION FOR 5 CHARACTERS IN ALFALFA

Leaders: J. H. Elgin, Jr., R. R. Hill, Jr., K. E. Zeiders, and K. T. Leath, Pasture Laboratory

The third and fourth cycles of selection to compare tandem, independent culling levels, sum of ranks, and index methods of selection for resistance to Uromyces striatus, Pseudopeziza medicaginis, Ascochyta imperfecta, and Leptosphaerulina briosiana, and recovery after cutting in flats in the greenhouse have been completed. Comparison of the means of a sample of single crosses included in the index method indicates that resistance to P. medicaginis is being increased, but little or no progress is indicated for the other characters. Methods cannot be compared until after the last cycle of selection.

Assuming that the index equation can be accurately determined, the index method of selection is theoretically best. Variability observed in estimates of the index equation for the first 4 cycles of selection indicates that the validity of this assumption is questionable.

Title: BREEDING AND STRAIN EVALUATION OF 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, R. R. Seaney, M. J. Wright and H. A. MacDonald, New York

Spring forage growth in New York in 1967 was much delayed (the average May temperature was 8° F below normal). Sustained high temperatures in early June produced very rapid growth. These temperature extremes had significant effects on alfalfa insect pests. The weevil, which is now reaching the major alfalfa area of the state, was delayed in development as in 1966 (1966 Annual Report, p. 50). Larval populations emerged late but peaked rapidly with the hot June weather. Effective spray control demanded precise timing. Leafhopper injury on regrowth harvests was very severe.

Variety performance in alfalfa under intensive management was generally affected by the weather - insect influences. First harvest removal was at an earlier than usual growth stage; this was followed by various degrees of weevil damage to regrowth shoots. Evidence indicates that spray timing and available insecticides which provide a practical level of weevil control on full growth forage may not be sufficient for full protection of regrowth. A small larvae population can do substantial damage on regrowth shoots. If initial harvest occurs during larval infestation, a new shoot feeding period of some duration occurs (hay curing, weather delays or ineffective applications). In effect, the normal minimum time interval between harvests is shortened if feeding occurs and harvests are made on time; precise management pressure effects are much less predictable even with careful attention to regrowth spray protection. Damage sustained is chronic and cumulative and obviously compounded with other increments of management pressure. Insufficient data are available to indicate specific variety interactions with these new growth conditions. The new vigorous varieties, Saranac and Iroquois, have been consistently and outstandingly superior in recent trials. Variety vigor is hardly a form of weevil resistance but higher vigor levels improve performance and improve chances of survival under the increased production pressures associated with the weevil and with control measures.

The value of including grasses with alfalfa grown under intensive management has been recently questioned. The contribution of grass, timothy in particular, is not readily apparent and its presence prohibits the use of several weed control chemicals during establishment. Several recent alfalfa variety trials have been overseeded with timothy on part of the replicates to determine its value in mixture with alfalfa under intensive managment. The following results (Table 1) were obtained in 1966-67 at two locations in New York with very diverse growing environments. Data are means of two replicates per trial; plots are sizeable areas consisting of entire replicate of the variety trial.

Table 1. Yield of alfalfa and alfalfa-grass mixtures in New York.

Mixture	Data in tons/acre @ 12% moisture			
	Aloquin, N. Y.		Herkimer, N. Y.	
	1966	1967	1966	1967
Alfalfa - alone	5.83	6.21	4.34	3.24
Alfalfa + Essex timothy	5.86	6.65	4.32	3.68
Alfalfa + Exptl. timothy variety	5.82	6.34	4.36	3.45

Both sites are excellent trials. In each, presence of timothy in mixture slightly changed distribution of production among harvests in the first season but total season yield was the same as no grass. In the second season, a substantial advantage was detected for the mixture versus alfalfa alone. Essex timothy is later in maturity and presumably less competitive than the experimental strain used. There is no current explanation why it has shown advantage under these circumstances. Similar comparisons are being made in additional trials.

Sheep intake and digestion trials comparing sudangrass, hybrid-sudan and sudan-sorghum forages in ensilage and greenchop form were continued in 1967. Hay from these materials was also included in the current season. Data are being summarized. Ensilage preservation in sealed plastic sleeves included vacuum packing in 1967. Materials were wilted to near 50% dry matter--only a very small amount of spoilage was found in one lot which exceeded this dry matter content.

In vitro and in vivo digestibility analysis procedures are being examined as screening techniques in plant selection. Genotype-environment interactions in timothy including locations and time of harvest as environmental variables are being studied.

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS

Leaders: R. P. Murphy and C. C. Lowe, New York

During the past three years several source nurseries of introductions and domestic breeding lines have been studied for new sources of desirable germ plasm (1966 Annual Report, p. 52). In particular, stress has been put on selection for tolerance or resistance to insect pests, particularly the alfalfa weevil and the potato leafhopper. The results of selections

based upon reduced larval feeding in the field were presented to the Eastern Alfalfa Improvement Conference at Ottawa, Canada, July 17-18, 1967. No plants have been found in these nurseries or old fields that are resistant to larval feeding in the field. There seems to be some tolerance to feeding in a few introductions and species of Medicago. These are being studied further by establishing new nurseries in the field from inbred and polycross seed of selected clones from the nurseries and old fields. Laboratory tests with larval or adult feeding have not been initiated although in preliminary tests some resistance to adult feeding and oviposition had been shown by the species Medicago carstiensis and M. pironae. These species are quite dissimilar to the cultivated alfalfas.

A program to develop inbred lines and to investigate their use in breeding improved varieties has been initiated. The relationship between several specific morphological characteristics such as flower color, multifoliolate leaflets, and spreading crowns, and vigor and adaptation is being investigated. Selection for the multifoliolate characteristic is being continued in order to determine if the leafiness can be increased and if this will be significant in increasing the nutritive value.

Title: INBREEDING AND HYBRIDIZATION OF BIRDSFOOT TREFOIL

Leader: T. E. Devine, New York

Crosses of selected S_6 inbred lines produced progeny with outstanding yielding capability in space plant trials. Yields exceeded the Viking check by 30 to 50%. Production of seed in sufficient quantities for trials under sward conditions is planned.

Title: SELECTION FOR WINTERHARDINESS IN A VIGOROUS INTRODUCTION OF BIRDSFOOT TREFOIL

Leader: T. E. Devine, New York

The variety Kimey, introduced from South America, is a vigorous upright strain. However, it is not sufficiently winterhardy for acceptable production in the Northeast. A selection program for winterhardiness in this variety is underway.

Title: SELECTION OF 2,4-D TOLERANT STRAINS OF BIRDSFOOT TREFOIL

Leader: T. E. DEVINE, New York

Four cycles of selection for tolerance to 2,4-D have been imposed on trefoil populations to develop a strain for use in a program utilizing this inexpensive herbicide for weed control during establishment and for maintenance of botanical composition in permanent stands. Observations during the selection program indicate progress in increasing tolerance. Seed production for field establishment and yield trials is planned.

Title: INCREASED SEEDLING VIGOR IN LOTUS CORNICULATUS THROUGH INTROGRESSION WITH L. TENUIS

Leader: T. E. Devine, New York

A program of selection for seedling vigor in populations derived from the hybridization of L. corniculatus and L. tenuis is underway. Screening is done by planting seed in vermiculite in 12" to 16" flats, each flat being a replication with two rows of Viking as a check. Average plant height in each row is recorded 3-4 weeks after planting. Several clones show a promising level of vigor.

Title: BREEDING CROWNVETCH FOR FORAGE AND SLOPE STABILIZATION USAGE

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

Preliminary studies of self- and cross-fertility in Coronilla varia under field conditions indicated that the species is relatively self-incompatible. During the winter of 1966-67, work was done to assess the self- and cross-fertility under greenhouse conditions. Fifty-eight plants were chosen at random from a field of Penngift crownvetch. Toothpicks tipped with carborundum paper were used to transfer pollen. Cross-fertility expressed in terms of seed set per flower ranged from 0.0 to 5.5. One case of cross-incompatibility was found. Self-fertility ranged from 0.0 to 0.85 seeds per flower pollinated. Two thirds of the plants set no seed when self-pollinated.

Title: RED CLOVER BREEDING INVESTIGATIONS

Leaders: J. A. Schillinger, F. Tawab, and Y. Somen, Maryland

Persistent red clover plants from a 1964 seeding were intermated in the greenhouse and will be used as a source population for future selection. Clones planted in a source nursery in 1966 were scored for their vigor and persistence in late 1967 and will be observed again in 1968. The most vigorous plants will be used as parents in red clover synthetics. A Turkish introduction of red clover was found to be highly resistant to the pea aphid Acyrthosiphon pisum (Harris). The inheritance of resistance to the pea aphid is being studied. Also, the effect of host plant resistance on virus transmission will be evaluated.

Attempts to make interspecific crosses between Trifolium medium, T. alexandrium, and T. pratense are being made at both diploid and tetraploid levels.

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

Leader: G. M. Dunn, New Hampshire

In 1967, average yields in a diallel single cross test of bromegrass were 3.66 tons/acre in Syn 1 versus 3.42 in Syn 2, a highly significant difference. Sixteen F_2 families, ranging from 90 to 877 plants each, were obtained of albino X normal. Eleven of these were segregating in ratios from about 18 green: 1 albino to 44 green: 1 albino. The other 6 families were all green. Selfing of the original albino mutant produced 4 green: 821 albino seedlings; no homozygotes have yet been found. Additional F_3 and backcross data are being obtained. In growth chambers, high temperature plus long days produced the greatest amount of greening and survival of albino seedlings.

Seedlings grown from single crosses of bromegrass mutants under cages indicated that a minimum of 9 to 18% selfing had occurred on certain mutant clones.

Title: SEED PRODUCTION OF LEAF DISEASE RESISTANT BROMEGRASS SYNTHETICS

Leader: C. C. Berg, Pasture Laboratory

Clones of bromegrass with resistance to several diseases have been combined into two experimental synthetics. Syn 1 seed was harvested from Syn D which is composed of 6 clones with resistance to Helminthosporium bromi and Stagnospora bromi. However, Syn 1 seed was not harvested from Syn E, which is composed of 7 clones with resistance to the above diseases and to Rhynchosporium secalis. About the time the Syn E plot had finished flowering some construction workers used the plot for a parking lot. Syn 2 seed was harvested from both Syn D and Syn E isolation plots. Hopefully both Syn 1 and Syn 2 seed of both synthetics can be harvested in 1968.

Title: MALE-STERILE ORCHARDGRASS

Leader: C. C. Berg, Pasture Laboratory

A nursery was established to determine if cytoplasmic factors are involved in the male-sterile material being studied at the Pasture Laboratory. This nursery of nearly 3000 plants that was examined in 1966 was examined again in 1967 for the occurrence of male-sterile plants. Although five more male-sterile plants were found, the results are no more conclusive than last year (1966 Annual Report, p. 8). It is quite possible that cytoplasmic factors are not involved, but there are no evident genetic alternatives.

Title: EVALUATION OF NONHEADING ORCHARDGRASS

Leader: C. C. Berg, Pasture Laboratory

The first generation (Syn 1) of the three 4-clone nonheading orchardgrass synthetics was evaluated for panicle production and forage yield at University Park for the third year. The heading response (i.e., panicles per square foot) in 1967 was similar to previous years. Pennlate, Syn A, Syn B, and Syn C produced 29.4, 13.2, 8.2, and 1.9 panicles/ft^2, respectively. In the two previous years at University Park and in Vermont, Pennlate yielded no more, or only slightly more forage (dry matter) than the synthetics. However, in 1967 the first cut yield from Pennlate was

about 0.6 tons dry matter per acre higher than Syn A or Syn B and nearly 0.9 tons dry matter per acre higher than Syn C. The second cut yields were between 0.5 and 0.6 tons dry matter per acre for all four entries. Syn 2 seed of each of these three synthetics has been produced at Prosser, Washington.

Title: THE BREEDING AND CYTOGENETICS OF PERENNIAL FORAGE GRASSES

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

Yields in broadcast plots were determined for a group of orchardgrass selections which included 23 clones selected for disease resistance and 100 medium late and 144 late polycross progenies and checks. In the later materials, several programs are performing well. An additional year's data will be collected before further selection and testing.

Performance data were collected on varieties and experimental synthetics at several locations.

A series of isolation cages was constructed to study the effects of light reduction, high temperature, and reduced air circulation on pollen quality and seed set in orchardgrass and bromegrass under cage environments. The study is designed to help establish the causes for the relatively poor seed set being obtained in producing grass seed under cages. In 1967, in vitro pollen germination and growth were not detectably different in the cage environment. Seed set in bromegrass was more adversely influenced by the several cage environments than was that in orchardgrass. In bromegrass, preliminary results indicate that light reduction was more adverse than heat buildup in reducing seed set. Circulating the air inside cages increased seed set.

Title: RYEGRASS-FESCUE INTERGENERIC HYBRIDS

Leader: C. B. Berg, Pasture Laboratory

Syn 1 seed production of 8 different 4-clone synthetics under muslin-covered cages was a complete failure. In early July, after anthesis, the heads were eaten by army worms (Cirphus unipuncta). However, Syn 2 seed was harvested from isolated plantings. Some 2n = 28 chromosome plants X tall fescue (2n = 42) crosses were successful, but nearly all attempts to cross 2n = 35 and 2n = 42 chromosome plants with tall fescue were unsuccessful.

Title: PROJECT NEM-22 - FACILITATING THE MARKETING OF SEED OF FORAGE AND TURF CROPS THROUGH DEVELOPMENT OF TECHNIQUES FOR EVALUATING VARIETAL PURITY AND IDENTITY

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

Cooperators: The New York (Geneva and Ithaca) and Pennsylvania Agricultural Experiment Stations, the Biological Science Branch, ARS, the Seed Branch, C and MS, and the Cooperative State Research Service, USDA

In New York a study was made of factors affecting growth habit of six varieties of perennial ryegrass. A high percentage of the plants of some varieties became decumbent when grown with long photoperiods, high light intensity, and cold dark periods. Varietal differences in percentage of decumbent plants and general appearance were great enough to make separation of some varieties possible. Clipping of greenhouse-grown ryegrass seedlings 19 days after planting also induced decumbency in some plants and was helpful in making varietal determinations.

When exposed to long photoperiods and cold dark periods plants of six timothy varieties varied in growth habit. The main stems of all plants grew upright, but tillers varied from upright to decumbent. Percentage of plants with decumbent tillers varied from 48 for Essex to 85 for Heidemiji.

Birdsfoot trefoil plants were grown with short photoperiods and cold dark periods. They were sprayed with B-995 and the primary stems were clipped off 8 days later. In response to these treatments varietal differences developed that made it possible to group varieties into three categories. Empire and Leo differed from Viking and European by being more nearly decumbent. Empire plants could be distinguished from those of Leo because of their darker green color, red stems, and small leaflets. The general appearance of Viking and European plants was similar, but there was some difference in growth habit.

Red fescue varieties differed in response to foliar applications of B-995, but response of plants was greatly affected by environment. In one experiment in which plants were grown with 16-hour photoperiods and 1,100 ft-c the percentage of decumbent plants of HF-1 and common red fescue was tripled by one application of B-995. With the same treatment decumbent plants of Chewings, Illahee, and Pennlawn were increased by only 50%.

Plants of several species were grown with a nutrient solution lacking phosphorus. In response to this treatment many alfalfa plants developed red stems. Varieties ranged from 23% red stemmed plants for Caliverde to 50% for Cardinal. Twelve Kentucky bluegrass varieties were given this nutrient solution. Plants of Atlas, Nugget, and Prato turned red but plants of the other nine varieties turned brown and died.

In Pennsylvania, work was continued on the application of various serological and chromatographic techniques that might be useful in varietal purity testing. Studies with antigens and antisera from several seed lots each of 9 varieties, strains, and sources of crownvetch indicated distinct serological differences. Paper, thin layer, and gas chromatographic techniques to categorize varietal differences continue to show promise. Work also continued on various color measuring devices to evaluate varietal differences in flower and leaf color of alfalfa, red clover, and birdsfoot trefoil and leaf color in bluegrass. Useful varietal differences were found in plants grown and measured under standardized conditions.

Studies were concluded on the use of various stress tests to evaluate seed vigor in reed canarygrass. A combination of the hot flood stress test (seed immersed in water for 5 days at 35° C followed by germination under standard conditions) and the standard laboratory germination test was useful in identifying seed lots of low vigor that performed poorly under stress conditions in the field.

In work at the Biological Science Branch of the Market Quality Research Division, electrophoresis of seed proteins from several varieties of soybean indicated few varietal differences. One protein fraction present in the variety Mandarin, and all varieties derived from it, was traced through three generations of plants and found to be simply inherited. A thin layer chromatographic method for detecting differences between annual and perennial ryegrass in certain protein constituents was developed. Techniques are available for bulk seed but detection at the individual seed level is still a problem.

In work at the Seed Branch, C and MS, field ratings of degree of resistance or susceptibility of alfalfa to bacterial wilt could not be duplicated with quick techniques in the growth chamber.

A simple test requiring about a week was developed for testing the resistance of several new soybean varieties to Phytophthora root rot. This can be accomplished in a germinator using rolled towels. Studies have begun using the same technique to test for resistance to downy mildew and bacterial pustule.

Field observations on varietal designation of cowpeas were carried out in cooperation with the Cowpea Nomenclature Study Group.

USEFULNESS OF FINDINGS:

Methods of varietal purity testing developed and evaluated under this project are of value in assuring the purchaser that the variety is correctly labeled and identified. This is important because few varieties can be identified by seed characteristics alone.

Section II

Plant Pathology, Entomology, Selection for Disease and Insect Resistance, Control, etc.

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

Leader: E. S. Elliott, Chairman, Regional Technical Committee

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

In Delaware, several varieties of alfalfa were inoculated with Fusarium oxysporum f. batatas and the amount of decay determined after five months. In 5-year-old plants, the test varieties (listed from greatest to least root decay) were: DuPuits, Atlantic, Buffalo, Narragansett, Ranger, Vernal, and Williamsburg; in four-year-old plants, DuPuits, Ranger, Cayuga, Narragansett, Alfa, Atlantic, Williamsburg, Buffalo, and Vernal. In other experiments, designed to find sources of stress, various quantities of KCl inserted directly into the taproots of alfalfa resulted in little visible differences in growth of several varieties, root tissues were not greatly affected but foliage was reduced.

In New Jersey, Pennscott red clover was grown in soil inoculated with F. roseum at constant soil temperatures of 12, 16, 20, 24, 28, and 32 C. Soil temperatures of 28 and 32 C were apparently unfavorable to the host but favorable for disease development as severe rotting developed. Least root injury occurred at 12 and 16 C. Adverse soil temperatures may serve as a stress factor on the host indirectly favoring clover root deterioration.

Field plots of Cayuga, Narragansett, Saranac, and Vernal alfalfa at four sites in New York are being utilized to follow rhizosphere-rhizoplane and nonrhizosphere soil acidity and the development of root rot. In stands of two-year-old plants the pH of the rhizosphere-rhizoplane varied from 0.0 to 0.7 pH units lower (avg. pH 5.9) and in three-year stands 0.2 to 0.9 units lower (avg. pH 6.4) than that of adjacent soil. Results of studies on interaction of aluminum ion toxicity (utilizing aerated solution culture procedures) and F. oxysporum in the development of root rot have been inconclusive but plants receiving less than 1 ppm aluminum ion in solution at pH 5.0-6.0 showed a tip dieback and the roots are readily decayed by Fusaria.

In Pennsylvania, DuPuits alfalfa plants growing in an axenic environment were cut every 2 weeks at 3 different levels; (1) cut to remove flower buds, (2) cut back to 6 inches, and (3) all but 4 mature leaves were removed. Half the plants were inoculated with F. tricinctum. One month after inoculation 5% mortality had occurred in set No. 3 (inoculated), and no deaths in set No. 1 (inoculated) or in the noninoculated controls. After determining carbohydrate levels, it was concluded that resistance to root rot and carbohydrate levels are altered by the amount of harvesting alone. Also, F. tricinctum alone can cause root rot of alfalfa but severity is related to the condition of the suscept.

Rhode Island reports that Fusarium reduces nitrogen fixing nodule formation on both susceptible Narragansett and resistant Cherokee. Seedlings of both varieties infected with F. oxysporum failed to support normal development of new nodules. Nitrogen content of seedlings concurrently inoculated with the bacterium and fungus was less than those inoculated only with Rhizobium. In the presence of Rhizobium on the root surface subsequent cortical infection was reduced and effective nodulation occurred. Gnotobiotic chambers have been developed that permit collection of the root exudate for analysis.

Studies made in West Virginia show that red clover vein mosaic virus (RCVMV) greatly reduces the amount of foliage produced in red clover. When the virus is in combination with each of four Fusarium species, varying effects have been noted. On the basis of the single isolate used F. oxysporum, F. roseum, and F. solani are more virulent than F. moniliforme. When these Fusarium spp. are in combination with RCVMV there is a more adverse effect upon the plant than when RCVMV or fungus is present alone. The addition of ATP either alone or in combination with guanosine, cytosine, uracil, or adenine sulfate, markedly increases the virulence of the virus and facilitates production of large numbers of red clover plants infected with RCVMV.

At the Regional Pasture Research Laboratory, it was found that the numbers of root borers (Hylastinus obscurus) feeding on red clover plants was not as important as the site of feeding within the root. When root borers entered the upper crown, xylem tissue was severely damaged and plants died whether the fungus (F. tricinctum) was present or not. In greenhouse tests, the addition of 20 larvae per plant of the clover root curculio (Sitona hispidula)did not increase root rot of Vernal and DuPuits alfalfa by F. tricinctum. Due to larval feeding damage to plants, the need for control of fungus flies during root-disease investigations in the greenhouse was demonstrated.

At Beltsville, work on related root rot-legume problem indicated that the pathogenicity of test fungi is greatly influenced by the choice of test container for greenhouse use. The influence includes a temperature effect; mean temperature of the soil mass is lowest in new clay pots, higher in old, discolored clay pots, and highest in plastic pots.

USEFULNESS OF FINDINGS:

Additional factors of the physical and biological environments which influence the pathogenic potential of Fusarium spp. have been clarified during the year. This information further emphasizes the need for a reevaluation of cultural practices now commonly used in forage legume production. Better control of root rot appears to be feasible through improved insect control, changes in cutting practices, fertilization procedures, and other methods. The data already available can be used by extension pathologists and other workers to alter recommendations for forage legume culture. Some of this information can also be utilized in producing forage legumes with greater resistance to Fusarium spp.

Title: FACTORS RELATED TO DEVELOPMENT OF ROOT ROT OF ALFALFA

Leader: F. L. Lukezic, Pennsylvania

Four-month-old DuPuits alfalfa plants in a germ-free environment were grown in modified Hoagland's solution in a sand-perlite mixture. Every 2 weeks the plants were cut at 3 different levels: (1) to remove flower buds, (2) back to a height of 6 inches, and (3) all but 4 mature leaves were removed. One month after the cutting started a suspension of Fusarium tricinctum spores was poured around the roots of half of the plants in each treatment. At the end of 6 months the plants were evaluated for disease severity. The root carbohydrate levels were determined by making trimethylsilyl derivates and using gas chromatography. The presence of the fungus reduced the amount of glucose, maltose and starch in treatment 1, but there was an increase in sucrose. In the other treatments there was a reduction in fructose, glucose, sucrose, maltose, and starch due to the cutting and the fungus magnified this reduction. Maltose could not be detected in the severely cut plants (3). The amount of arabinose and xylose was reduced by cutting, but was increased by inoculation with the fungus. Disease severity was related to cutting. There was 75% mortality in set No. 3 (inoculated), 25% mortality in set No. 2 (inoculated), and no deaths in set No. 1 (inoculated or the noninoculated controls).

Title: RESISTANCE TO SCLEROTINIA TRIFOLIORUM ERIKS IN SELECTED ALFALFA CLONES, S_1 AND POLYCROSS PROGENY

Leaders: J. A. Schillinger and O. D. Morgan, Maryland

Parental clones along with their S_1 and polycross progenies were evaluated for their resistance to Sclerotinia root rot. Selections from long-termed stands in Maryland and those from the variety Narragansett have shown the highest levels or resistance (1966 Annual Report, p. 37).

Title: INVESTIGATION OF MYROTHECIUM LEAF SPOT

Leaders: F. L. Lukezic, Pennsylvania; and J. H. Graham, Pasture Laboratory

The investigation of a leaf spot of red clover caused by Myrothecium spp. has been concluded. (See List of Publications, Cunfer.)

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

Leader: C. A. Martinson, New York

Studies were initiated in 1968 to investigate the role of plant nutrition in the development of root rot and crown rot by Fusarium spp. Major emphasis will be placed upon potassium and iron nutrition and aluminum toxicity and the significance of an imbalance of these minerals on pathogenesis by the Fusarium spp. and host tissue susceptibility. No results are available.

Title: RELATIONSHIP OF SOIL TEMPERATURE TO ROOT DETERIORATION IN RED CLOVER

Leaders: Philip M. Halisky and Wasi M. Siddiqui, New Jersey

A greenhouse study was designed to determine the relationship of constant soil temperatures to root rot development in red clover. Month-old seedlings of Pennscott red clover were inoculated with Fusarium roseum and transferred to a series of constant temperature tanks maintained at 12, 16, 20, 24, 28, and 32 C, respectively. Five months later the roots were dug, rated for severity of rotting, and subjected to standard laboratory isolation procedures. Since red clover generally thrives in cool, moist climates, growth was adversely affected at 28 and 32 C. Such relatively high soil temperatures probably constituted a stress on the host, thereby favoring disease development. Predictably, least root deterioration developed at 12-16 C and most at 28-32 C (Table 2). In general, the numbers of Fusarium colonies isolated from visibly lesioned clover roots also increased with higher soil temperatures and with greater root deterioration as measured by the rating scale (Table 2).

Table 2. Relationship of constant soil temperature to root rot development in Pennscott red clover inoculated with Fusarium roseum.

Temperature C	No. plants examined	Root rot rating[a/]	No. Fusarium colonies isolated[b/]
12	23	2.4	16
16	27	3.3	30
20	25	4.5	40
24	31	6.1	38
28	26	9.7	44
32	24	9.0	45
LSD .05	--	.54	2.6

a/ Scale used for rating root rot was 1 (least) to 10 (most).

b/ Number of colonies isolated from 50 random root samples per temperature.

Title: INTERNAL BREAKDOWN OF RED CLOVER

Leaders: K. T. Leath and K. E.Zeiders, Pasture Laboratory

The cause of internal breakdown (IB), a pith deterioration that occurs in crowns of red clover, is still unknown. Evidence indicates that the disorder is physiogenic, and gnotobiotic growth studies are currently being performed to eliminate conclusively bacteria and fungi as possible causal agents.

Reports indicate that the incidence of IB is positively correlated with crown diameter. When red clover plants were fitted with glass collars to restrict crown diameter to a maximum of 7 mm, IB in the restricted crowns was less than half that which occurred in larger unrestricted crowns.

Title: ROOT INSECT-DISEASE COMPLEX

Leaders: K. T. Leath, R. C. Newton, and R. R. Hill, Jr., Pasture Laboratory

The aspect of feeding by root insects as a predisposing factor rather than merely a vector factor is being investigated in connection with fusarial root rot and wilt. Greenhouse and laboratory methods to investigate the relationships of root-feeding insects and root-rotting fungi are being developed.

The necessity of controlling fungus flies during root rot investigations in the greenhouse was demonstrated. Larvae of a Bradysia sp. fed upon alfalfa and red clover roots which resulted in death of seedling plants in both soil and nutrient-solution culture. Insect-damaged plants of red clover inoculated with Fusarium roseum and insect-damaged plants of alfalfa inoculated with F. oxysporum f. sp. medicaginis had significantly higher mortality rates than undamaged, inoculated, control plants.

Title: CROWN RUST RESISTANCE IN TALL OATGRASS INTRODUCTIONS

Leaders: D. D. Dolan and S. W. Braverman, New York (Geneva)

Eighty-seven tall oatgrass introductions, Arrhenatherum elatius (L.) Presl were tested in the field and greenhouse for possible resistance to crown rust, Puccinia coronata var. avenae Fraser and Led. Seedlings were inoculated under controlled environmental conditions in the greenhouse. Reinoculated survivors were field planted, maintained as individual plant selections, and observed over a three-year period. Seed harvested from rust-resistant plants was further tested by inoculating resultant seedlings with the crown rust organism. New P.I. numbers assigned to the rust resistant selections are P.I.'s 323481-495, A. elatius and P.I. 323496, A. erianthum Boiss. and Reut.

The disease incitant was tested on 10 differential oat varieties in an attempt to determine the race of P. coronata var. avenae. In two separate tests, the varieties Anthony, Appler, Bond, Santa Fe, Ukraine, and Saia were susceptible to the pathogen. Landhafer, Trispernia, Bondvic, and Victoria were resistant. These results suggest the presence of a new race of crown rust. Dr. M. D. Simons, Ames, Iowa assigned number 449 to the race of crown rust attacking tall oatgrass introductions in the plant introduction plots, Geneva, N. Y.

Title: FORAGE CROP INSECTS IN MASSACHUSETTS IN 1967

Leaders: F. R. Shaw, M. C. Miller, James Matusko, Dallas Miller, and C. P. S. Yadava, Massachusetts

Population studies of forage crop insects were conducted from May 19 to August 15, and of alfalfa weevil to mid-November (see Table 3). The alfalfa weevil continued to be the most numerous single insect pest of alfalfa but was less abundant than in 1966 (see 1966 Annual Report, p. 42). On the whole, damage by this insect was less extensive in 1967 than during 1966. The population of pea aphids increased in 1967 approximately doubling its 1966 abundance (17.88% of total in 1967). However, it has not reached the proportions observed in some previous years when it represented 50-60% of all forage crop pests. Plant bugs also showed an increase in abundance from 3.7% in 1966 to 12% in 1967. Leafhoppers were much more numerous, increasing from 0.80% in 1966 to 12.7% in 1967. Spittlebugs (Philaenus spumarius) increased from 0.87% in 1966 to 2.7% in 1967.

Parasitism of the alfalfa weevil by Bathplectes curculionis increased in 1967. Alfalfa weevil larvae parasitized by Bathplectes were collected from May 28 to July 13. Between June 5 and 15 the percent parasitism ranged from 1 to 90, whereas in 1966 the highest percent of parasitization was 60. Alfalfa weevil larvae parasitized by Tetrastichus incertus were collected from June 5 through October 1. Parasitism ranged from 17 to 80% during July; this was somewhat lower than in 1966.

Studies of the mating behavior and oviposition of Tetrastichus incertus have been made.

Preliminary studies were conducted to determine host preferences of coccinellids, nabids, ants, spiders, and pentatomids. Six species of coccinellids were provided choices of alfalfa weevil larvae, aphids, and nymphal leafhoppers and plant bugs. All six preferred aphids to alfalfa weevil larvae. A distinct preference was observed for the earlier instars of the weevil larvae. Some species of coccinellids preferred leafhoppers to alfalfa weevil larvae. Three species of Nabis were provided choices of alfalfa weevil larvae, nymphs of leafhoppers and plant bugs, aphids and caterpillars; they preferred aphids and alfalfa weevil larvae to the other insects. When given a choice of alfalfa weevil larvae and aphids, two of the three species preferred the larvae but one species of Nabis definitely preferred aphids. Ants seemed to have little choice between weevil larvae, aphids and small leafhoppers. They seemed to prefer dead to living specimens. However, ants have been observed to be carrying live specimens of alfalfa weevil larvae. Pentatomids appeared to prefer the larvae of caterpillars to those of the alfalfa weevil.

A number of pesticides or pesticide combinations were evaluated in 1967, as follows: Melathion (16 oz) plus Cygon (4 oz); Thimet 600 (2 levels); Baygon EC; Baygon WP; Bay 29443 SC; Baygon and Bay; Baygon EC and Guthion; Zolone; Dursban; Methoxychlor; Niagara 10242 WP; Imidan 3 E; Imidan WP 50;

Stauffer N 45432E. The applications were made on June 27 with compressed air sprayers and one gallon of diluted spray per plot. The average heights of alfalfa for 3 blocks were 4.6, 4.9, and 5.8 inches. On the day following application there were no significant differences between treated and untreated plots but differences appeared later.

Table 3. Census of forage crop insects in Massachusetts in 1967.*

Insect name or group	Percent of total
Alfalfa weevil	48.97
Pea aphid	17.88
Leafhoppers	12.71
Plant bugs	12.00
Spittlebug (Philaenus spumarius)	2.70
Grasshoppers	.80
Lepidoptera	.63
Miscellaneous beetles	.60
Sawflies	.52
Sitona hispidula	.12
Beneficial Arthropods:	
Nabis ferus	1.29
Coccinellids	.59
Parasitic Hymenoptera	.49
Spiders	.44
Syrphids	.15
Chrysopids	.06
Pentatomids	.03

* Based on collection of 43,757 specimens.

The week following application all pesticides were significantly better than the checks in the control of alfalfa weevil. The second week after treatment, the highest mortalities resulted with Stauffer N 45432E, Niagara 10242, Baygon WP, Dursban, Zolone, Imidan WP and Imidan EC in a descending order as listed but the differences were not significant. At the end of the third week, the highest mortalities were obtained with Dursban, Imidan WP, Zolone, Baygon and Guthion, Niagara 10242, Bay 29493, Imidan 3 E, Thimet (at 1/2 lb per acre), and Stauffer N 45432E, arranged in a descending series. There was no significant difference among the pesticides; all were better than the check.

By the end of the first week, all treatments for leafhoppers were better than the checks except for Baygon EC and Bay 29493, Baygon WP and Thimet

(at 1/2 lb per acre). Subsequent examinations showed no difference between plots receiving pesticides and the checks.

One week after treatment, Niagara 10242, Zolone and Thimet were significantly better than the other treatments in the control of aphids. Two weeks after treatment, Zolone, Niagara 10242, Dursban, Malathion and Cygon, Thimet (at 1/2 lb per acre), Imidan 3 E, and Stauffer N 45432E were significantly better than the other pesticides and the check. By the end of the third week, Zolone, Imidan WP, Bay 29493 and Niagara 10242 were significantly better than the other pesticides.

Title: ALFALFA WEEVIL DEVELOPMENT AND CONTROL AS RELATED TO ENVIRONMENTAL CONDITIONS, ALFALFA CUTTING MANAGEMENT, AND TIME OF INSECTICIDE APPLICATION

Leaders: B. E. Dethier, C. J. Nelson, R. F. Lucey, M. J. Wright, G. G. Gyrisco, and C. C. Lowe, New York

A new project was inaugurated in 1967 with the establishment of (a) several new stations for the collection of air and soil temperatures to be related to weevil population data; (b) field experimental sites for studies of the interaction of cutting, spraying and insect infestation; and (c) a network of field sites throughout the state in which extension agents record crop growth and insect damage as the season advances.

Many of the observations have not yet been analyzed but it is clear that in 1967 precise timing of insecticidal sprays was necessary to achieve control; that cutting alone did not suffice to control the weevil; and that rate of buildup of the insect and rate of development of the crop were not closely enough synchronized from place to place to permit a uniform recommendation regarding the relationship between time of cut and time of spray.

Title: GRASSLAND INSECT INVESTIGATIONS

Leaders: S. R. Race and G. P. Dively, New Jersey

The alfalfa weevil is the most important insect pest affecting New Jersey agriculture. Five recommended and seven experimental insecticides were applied to alfalfa plots in May 1967 to determine their alfalfa weevil control performance. Each of the recommended materials satisfactorily controlled weevils. One experimental material, methyl parathion, has been added to the 1968 recommended list for New Jersey growers. Several other experimentals showed promise, namely: Imidan, Baytex, and Baygon.

The alfalfa weevil overwinters both in the adult and egg stages in New Jersey. Fluctuating and severe winter (1966-67) temperatures killed 70%

of fall-laid alfalfa weevil eggs in a test field by April 1967. If such conditions exist yearly, winter flaming of stubble to control overwintering eggs would not be practicable in New Jersey as it is in other areas.

Other research showed that adult weevil survival was greater in weedy and trashy fields than in pure stands of alfalfa; that adult female weevils preferred new growth alfalfa to stubble, bud stage, or full growth alfalfa for oviposition; and that the greatest number of overwintering eggs was located in the stems at 3 to 4-1/2 inches above the ground.

Title: SELECTION FOR INSECT RESISTANCE IN ALFALFA

Leaders: R. R. Hill, Jr. and R. C. Newton, Pasture Laboratory

Two cycles of index-selection for resistance to the meadow spittlebug, potato leafhopper, and alfalfa weevil have been completed using procedures given in previous Annual Reports (see 1966, p. 3). Results to date indicate that use of a small sample of single crosses to obtain estimates of variance and covariance components needed to calculate the index equation is not sufficiently accurate, cold treatment of spittlebug eggs is not essential for good hatch, and little or no progress can be expected in selection for weevil resistance with the present methods.

Polycross progenies from individual clones were planted separately in cycle 3. Mean squares for family means and plants in families will provide estimates of variance and covariance components with much higher degrees of freedom than the sample of single crosses. This should provide a more accurate index equation.

Flats of oat stubble are no longer stored in the cold room after the spittlebug egg laying period in September. Resistance to the alfalfa weevil will probably not be considered in future cycles of selection. This will permit a greater selection intensity for spittlebug and leafhopper resistance. (See List of Publications, Busbice et al.).

Title: EVALUATION OF REGISTERED AND EXPERIMENTAL INSECTICIDES FOR CONTROL OF THE ALFALFA WEEVIL IN PENNSYLVANIA - 1967

Leader: A. A. Hower, Jr., Pennsylvania

Registered and experimental chemicals were evaluated against the alfalfa weevil at State College and Hershey, Pennsylvania. Plot sizes were 20' x 100' or 40' x 100' in the case of the registered chemicals and 21' x 21' for the experimental chemicals. All materials were replicated 4 times in

complete random block design and applied with a tractor-mounted or a hand-operated sprayer. Approximately 30 gallons of H_2O/acre at 50 psi was used to apply the various chemicals. Larval counts were taken on 7, 14, and 21 days after application by means of a 15" sweep net. All larvae were returned to the plots after counts were made. Phytotoxicity was apparent with a few chemicals; the most severe being Sevin at 1.5 lb active ingredient/acre. This phytotoxicity, along with its level of control over the past several years, resulted in the deletion of Sevin from the list of materials recommended for use in Pennsylvania in 1968. Based on the 1967 and previous years data, methyl parathion at 1/2 lb active ingredient/acre is the major recommended material for alfalfa weevil control in the present spray schedule. UC 34096 at 1 and 2 lb active ingredient/acre and Nia 10242 at 1/2 and 1 lb active ingredient/acre gave the best control among the non-registered materials tested. A crude oil XMTY 97D applied early at 40 gallons/acre gave, in addition to weed control, a level of weevil control that warrants its further analysis.

Title: COMPARATIVE EFFECTIVENESS OF SIX INSECTICIDES ON ALFALFA WEEVIL LARVAE

Leader: John Wm. Neal, Maryland

Six materials were tested on 100 sq. ft. plots with each treatment replicated 4 times (1966 Annual Report, p. 38). Materials were applied April 20, 1967 at a time when larval damage to the crop was severe. Larval emergence in 1967 was 3 to 4 weeks earlier than in preceding seasons. Initial results at 10 days indicated fairly uniform control for all chemicals. A second survey at 22 days by sweep net showed Methoxychlor at 1.5 lb per acre to give continued effective control. Guthion (.75 lb), Malathion (1.25 lb), Sevin (1.6 lb) and Methyl Parathion (.5 lb) gave essentially equivalent control. These four compounds were half as effective (by larval count) as Methoxychlor but still gave good control. Imidan (1 lb) was the least effective, however, the difference was not significant from the preceding four compounds. The trial conditions were extremely difficult which demonstrates Methoxychlor's consistent reliability.

Title: EXPERIMENTAL ALFALFA WEEVIL CONTROL IN WEST VIRGINIA

Leader: C. K. Dorsey, West Virginia

The alfalfa weevil control research was designed to develop an integrated program. Pesticidal chemicals were applied with hydraulic sprayers, ultra-low-volume ground sprayers, a low volume air sprayer (helicopter), dusters, granules spreaders. LP-gas flaming experiments were continued with successful results. Satisfactory control was achieved by combining flaming (March) and foliar (April) treatments. Low volume and ULV spray applications with certain insecticides, applied either by ground or air equipment,

produced excellent control. Among the experimental (unlabeled) insecticides, NIA-10242 (Furadan) sprays gave excellent control. Azinphosmethyl, malathion, and methyl parathion sprays produced good to excellent control when applied properly.

Section III

Production, Management, Species Evaluation, Soil Fertility, Weed Eradication, Engineering, etc.

Title: ALFALFA CUTTING MANAGEMENT

Leaders: R. Lucey and R. Seaney, New York

These experiments were designed to study harvest management of first or seeding year stands of alfalfa. Clear stands of Iroquois and Saranac were established May 2, 1967 at Ithaca and Valatie, New York. Eight cutting treatments, i.e., four dates of first harvest and subsequent harvests at six or eight-week intervals, were compared for forage yield. Yields ranged from 3.0 to 4.5 tons per acre (15 percent moisture).

Total seasonal yields for different dates of first cut were approximately the same. However, yields of plots cut at six-week intervals were slightly higher than those cut at eight-week intervals. Saranac yielded about 0.5 tons per acre more than Iroquois.

All treatments will be harvested uniformly in 1968, to measure residual effects of seeding-year management. Other measurements taken in these studies include plant height, stand counts, leaf stem ratios, and *in vitro* digestibility determinations of stems, leaves, and whole plant.

Title: STUDIES ON ALFALFA VARIETIES, SEEDING RATES AND METHODS TO ACHIEVE OPTIMUM FORAGE PRODUCTION IN THE SEEDING YEAR

Leader: W. D. Pardee, New York

In the first year of this study tests were established at three locations in New York. Two cuttings were harvested, one in mid-July and the other about September 1. Yields ranged from 2 to 3.5 tons per acre. Seeding rate comparisons included rates of 12, 18, 24, 36 and 48 pounds of seed per acre. Yields generally increased with each increment; however, optimum economic yields occurred at 18 and 24 pounds per acre. Comparisons between seeding methods showed no difference between band seeding (with packer wheels) and Brillion seeder at two locations, with band-seeded plots yielding higher at the third site. In variety comparisons DuPuits provided only slightly more first-year production than Vernal.

These tests are part of a cooperative project with Dr. Don Graffis at the University of Illinois and Dr. Jack Winch at the University of Guelph, Ontario. Their first-year results were similar to those reported above. Future plans call for a repeat of these seeding tests and also the harvest of subsequent year yields to determine whether the effect of higher seeding rates carries into the next year of production.

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

Leaders: M. J. Wright and C. A. Martinson, New York

Yields of Cayuga, Narragansett, Saranac and Vernal alfalfas under 5 cutting systems have been compared at four locations in New York State. Two tests have been underway for two years, the others for one. Late fall cuts that simulate grazing have seriously reduced yields in the second year. Effects of a late 3-cut system are not yet distinguishable from those of an "on-time" 3-cut system. The two-cut system appears to be superior at the high-elevation (1500 ft.) site. Saranac has been the most productive variety to date. Extra potassium fertilizer has not yet proved advantageous.

Root samples were taken from plots at three sites late in the fall of 1967. Root-rot and crown-rot were light, but damage due to feeding by the larvae of the clover root curculio Sitona sp. was severe. Vascular browning in the taproot was evident and it had originated from sites of deep feeding. Fusarium sp. were commonly isolated from this necrotic tissue. Root rot development will be followed in 1968, especially to determine the role of insect injury.

Title: MANAGEMENT FACTORS ON PRODUCTIVITY PERSISTENCE AND FORAGE QUALITY OF ALFALFA

Leader: J. B. Washko, Pennsylvania

Forage production in 1967 of 31 alfalfa varieties was not adversely affected by taking 3 harvests as compared with 2 harvests during the previous establishment year. Two varieties, Moapa and Sonora, which showed considerable promise in 1966, winterkilled badly during the 1966-67 winter. Yield differences between early Flemish type varieties and later varieties were minor. Frequency of harvest had a pronounced effect on forage production and on stand persistence of adapted varieties. Harvesting at 25- and 30-day intervals was too drastic and resulted in low yields, loss of stand, and ingress of weeds. Harvesting schedules of 35 and 45 days showed up best. Applications of N after each cutting increased dry matter yields only slightly and encouraged weed encroachment. Favorable growth response was obtained with K_2O and minor nutrient applications.

Title: MANAGEMENT OF ANNUAL FORAGE SPECIES FOR QUALITY FORAGE

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

Adapted corn hybrids outyielded 22 sorghum-sudangrass hybrids, 2 hybrid sudangrass, and 1 open-pollinated sudan variety in dry matter production at 4 locations in the state. Forage production of 2 sorghum-sudan hybrids and 2 sudangrasses was greater when harvested at the silage stage (fully headed) than when harvested at the hay stage (36 inches high). When these varieties were cut at stubble heights of 2", 4", and 6", forage yields increased with higher stubble heights. When row spacings of 40 inches in single and double rows were compared with single 30-inch rows for corn hybrids at plant populations from 20,000 to 50,000, more silage was produced with the 30-inch row spacing. No yield advantage was obtained by using double rather than single rows at 40-inch spacings. Highest silage yields were obtained at the 50,000 plant population.

Title: THE SELECTION AND MANAGEMENT OF FORAGE SPECIES FOR HORSES

Leaders: J. B. Washko and T. L. Merritt, Pennsylvania

Four forage mixtures were compared in 1/2 acre paddocks for forage production in 1967. The most productive paddocks resulted from a seeding with 8 pounds. Viking birdsfoot trefoil, 4 pounds Kentucky bluegrass, 4 pounds Saratoga smooth bromegrass, and 2 pounds Climax timothy per acre. A mixture of 8 pounds each of Kentucky bluegrass and Saratoga smooth bromegrass,

4 pounds of Climax timothy, and 1 pound of ladino clover gave the next most productive forage. Kentucky bluegrass, Saratoga smooth brome, and Climax timothy, with either Vernal alfalfa or 100 pounds of nitrogen, applied in split applications of 50 pounds each, yielded approximately the same amount of forage. When horses were allowed to express their preferences for forage species among 38 mixtures seeded in small replicated plots cafeteria style, a high degree of selectivity was noted. First choice among the grasses was Kentucky bluegrass whereas among the legumes it was white clover. Horses also exhibited a high degree of preference for a mixture of Kentucky bluegrass, timothy, and white clover and a mixture of Kentucky bluegrass, smooth bromegrass, timothy and ladino clover.

Title: EVALUATION OF FORAGE SPECIES AND MIXTURES FOR HAY PRODUCTION

Leader: A. M. Decker, Maryland

Hay production of Williamsburg alfalfa, alfalfa-grass, Chesapeake red clover, red clover-grass, and pure grass stands have been compared during the past three growing seasons (1966 Report, p. 33). Saratoga bromegrass and climax timothy were grown with both legumes and reed canarygrass was grown with alfalfa. Pure stands of Saratoga, Lincoln, Climax, Clair and commercial timothy were compared.

Average yields of red clover and red clover-grass mixtures (4.05 and 4.52 T/A) for the first harvest year was within 0.33 tons of that obtained from comparable alfalfa treatments. During the second harvest season, however, alfalfa had a 1.80 ton advantage. By the third harvest year most of the red clover stands were gone while alfalfa was still productive. This was true whether the clover was seeded in the spring or fall prior to the first full harvest season.

Title: PRELIMINARY INVESTIGATIONS IN CROP PRODUCTION

Leader: P. R. Henderlong, West Virginia

Preliminary data indicate that crownvetch and birdsfoot trefoil as well as alfalfa can be successfully established in mid to late summer with the band seeding method. However, crownvetch and birdsfoot trefoil must be seeded earlier than alfalfa to assure a successful stand (before August 15 in the Morgantown area). The response to banded fertilizer by crownvetch seedlings is neither as pronounced nor as consistent as that obtained by alfalfa seedlings. The emergence of crownvetch seedlings in controlled environmental chamber studies was better with .5 and 1.5 inch planting depths than with surface planting. The reverse was found for white clover. The optimum temperature was 70 F ($\pm 10^{o}$) for crownvetch and 70 F ($\pm 20^{o}$) for white clover.

Title: SOD SEEDING ESTABLISHMENT STUDIES

Leader: A. M. Decker, Maryland

Kentucky bluegrass pastures renovated and seeded to an orchardgrass-ladino-red clover mixture were productive only during the first two years (1966 Report, p. 34). In contrast, yields from sod-seeded plots of crownvetch or birdsfoot trefoil and plots topdressed with LNPK increased in production each year. During this third harvest year forage yields in tons per acre were: unimproved sward, 0.73; orchard-ladino-red clover, 1.48; trefoil, 1.83; crownvetch, 2.92; LPK without N, 1.63; and LPK with 100, 200, and 400 lb N/A, 2.67, 3.58, and 5.77, respectively. Sod seeding plus fertilization offers an easy economical way to increase production of permanent cool-season pastures. A comparison of cool-season annuals and perennials sod-seeded into 'Midland' bermudagrass was made for the second season. Dry matter yields were 1.5 more from the annuals. In addition, Midland stands were better maintained with the annuals. Hairy vetch sod-seeded with small grains increased yields as much as did an extra 200 lb N per acre on Midland-small grain combination.

Title: FORAGE CROP ESTABLISHMENT

Leader: R. C. Wakefield, Rhode Island

Seeding at four dates ranging from May 1 to July 7 resulted in establishment of similar numbers of alfalfa plants per unit area although weed competition varied markedly during the period. Competition by wild radish was severe at early seedings and by annual grasses at later seedings. A combination of bromoxynil and dalapon was the most effective herbicide treatment. Bromoxynil controlled small wild radish plants and other broad-leaved species. Dalapon was effective against crabgrass and yellow foxtail. Increasing the seeding rate of alfalfa had little or no competitive advantage in establishing the legume. (See Leonard and Wakefield, List of Publications.)

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, Maryland

A uniform stand of 'Midland' bermudagrass was fertilized with 0, 200, 400 and 600 lb N per acre for the third harvest season and harvested 4, 5, and 6 times (1966 Report, p. 34). Dry matter production obtained from a replicated small-plot study ranged from 0.79 tons with no N and harvested six

times, to 6.68 tons with 400 lb N and harvested four times. The response to nitrogen above 400 lb was small. Three large areas were harvested for animal evaluation. These areas were managed so that forage was available for harvest at comparable stages of growth in early summer, mid-summer, and late summer. Forage from each field was harvested early (approx. 1 month of growth) and late (approx. 2 weeks after early harvest). These six hays are now being fed to determine intake and digestibility.

Title: GROWTH RESPONSES OF CORN AND ALFALFA TO SOIL FERTILITY AND IRRIGATION

Leader: N. A. Clark, Maryland

This study was revised in 1967 to include 3 irrigation treatments as whole plots. The irrigation treatments are: overhead irrigation, sub-irrigation, and no irrigation. Sub plots consist of: corn grain, corn silage, double crop wheat silage-corn silage, and alfalfa. Each of these crops is grown under soil test recommendations for fertility, one-half soil test, and double-soil test rates. The past year was devoted primarily to establishment of the study as many mechanical problems were encountered in the installation of the subirrigation system. This system consists of half-inch plastic pipe at a depth of one foot and placed at 3-foot intervals. The pipe has .03" holes at one-foot intervals. Rainfall was so abundant in 1967 that there was no response to irrigation. The installation is now complete and data will be collected in 1968.

Title: RELATION OF SOIL TEMPERATURE AND PLANT SPECIES TO RESPONSES TO PHOSPHORUS

Leaders: R. R. Robinson and C. F. Gross, Pasture Laboratory

Earlier studies in growth chambers (1966 Report, p. 10) showed far more rapid growth of red clover seedlings at 20° soil and air temperatures than at 10° soil and air temperatures. For equal growth periods both actual and percentage increases in yield from P fertilization were far greater at 20° than at 10°. For comparable stages of seedling growth, however, the increases in yield from P fertilization were approximately the same for the two temperatures.

This year seedlings of red clover and of northern and southern varieties of alfalfa (Vernal and Moapa, respectively) were grown with soil and air temperatures controlled independently. The temperatures were (1) 12° soil and 21° air; (2) 21° soil and air; and (3) 27° soil and air. There were 5 levels, 0, 30, 60, 120 and 400 mg P per pot (1500 gm of a soil-sand mixture). Nutrients other than P were not limiting. The yields of tops and roots were determined for comparable stages of growth.

The three test crops showed similar yield responses to temperature and similar responses to P at any one temperature. Soil temperature, however, had a marked effect on the responses to P. Responses to light applications of P were relatively poor at the lowest soil temperature but responses to heavy applications of P were greater than at a higher temperature. This is not consistent with results of earlier trials at constant soil and air temperatures, where responses to P for comparable stages of growth were similar. In the present trials, however, the root system at low soil temperatures was poorly branched in the lower half of the pot. Undoubtedly, this was a factor contributing to the poorer growth except where high levels of P were maintained. This adverse effect of low soil temperature on root distribution in the lower half of the pot was far greater than was observed in earlier trials where air temperature, as well as soil temperature, was low.

Title: FACTORS AFFECTING COMPETITION BETWEEN GRASS PLANTS AND CLOVER SEEDLINGS

Leaders: C. F. Gross and R. R. Robinson, Pasture Laboratory

There has long been speculation as to whether the difficulty in establishing clover seedlings in vigorous grass sods is associated with grass root exudates that are toxic to the clover seedlings or if it is a problem of small seedlings competing with a well-established sod (1966 Report, p. 10). In further studies ladino clover seedlings were grown alone and in association with established orchardgrass in nutrient cultures in the greenhouse. Techniques were devised to control competition for light. The nutrient solutions were of two concentrations and were either changed frequently or not changed during the experiment. When the solutions were not changed the pH values were controlled and the nutrients replenished.

The results are of particular significance in pasture management. Where the techniques succeeded in eliminating the competition for light, water, and nutrients there was no evidence that vigorous, well-established orchardgrass plants inhibited the growth of ladino clover seedlings. The evidence from these studies suggests that problems of establishment of clover seedlings in vigorous grass sods are associated with some phase or phases of plant competition or possibly with complex relationships involving soil microorganisms rather than with a release of phytotoxic substances by the grass roots.

Title: COMPETITION OF POTASSIUM BY GRASS-LEGUME ASSOCIATIONS

Leaders: C. F. Gross and R. R. Robinson, Pasture Laboratory

Results for the 4th harvest year (1966 Report, p. 11) were obtained in a field plot study of the competition for K between alfalfa and orchardgrass

seeded in alternate rows 7 inches apart and in mixed rows with different rates and placements of K fertilizer. The 1967 growing season was the first in which there was adequate rainfall since the trial started. Total forage production was approximately twice that of any preceding year.

At low levels of available K the seeding of alfalfa and orchardgrass in alternate rows rather than in mixed rows greatly reduced the species competition for available K. Both the yield and the K content of the alfalfa in alternate rows were much higher than in mixed rows. At high levels of available K there was no apparent advantage of the alternate row seeding. Potassium fertilizer applied directly over the alfalfa row was less efficient than the same amount of K applied broadcast.

Alfalfa roots, regardless of fertilizer treatment, had been damaged by insects and relatively few lateral roots were present even though a careful spray program had been followed for insect control. Lateral roots were regenerated when the alfalfa plants were transplanted and grown in the greenhouse. Regeneration of lateral roots in the field will be investigated with and without measures to control further insect damage.

Title: CROP AND PASTURE RESPONSE TO LIME AND FERTILIZER APPLICATION IN RELATION TO PROPERTIES OF WEST VIRGINIA SOILS

Leader: R. F. Keefer, West Virginia

Orchardgrass hay plots were established at two locations on Gilpin silt loam soil in Taylor County, West Virginia. Treatments were applied on triplicate plots at each location with 3 rates of N, 4 rates of P, and 3 rates of K plus check plots with no fertilizer applied. The initial pH was about 6.0, the available P was medium, and the available K was medium at both locations.

Significant yield differences were observed among N fertilizer rates of 0, 120, 240, and 480 lb per acre. No appreciable yield increase was evident where P or K were varied with constant amount of N applied (120 lb per acre). Approximately doubling the soil test rate increased the yield sufficiently to justify the additional expense due to added nitrogen. These preliminary results seem to indicate that our soil test recommendations for N are low. Very high rates (3-4 times soil test rate) increased the yield but this may not have been economical.

Pasture cages (4' x 4') were set out on Gilpin silt loam soil at 5 locations in Taylor and Barbour counties. On three of the sites, bluegrass pasture was fertilized with a 2-1-1 ratio at 0, 100, 150, and 200 lb of N and proportionate amounts of P and K. These sites tested low in P, and medium to very high in K. The lowest fertilizer treatment (approximate soil test amounts) yielded significantly more than the controls. Increase in fertilizer applied did result in additional response; however, this was of low magnitude and was not significant.

On the other 2 locations, white clover was abundant, hence no nitrogen was used but only P and K. None of the treatments was significantly different from the controls. At one location the soil tested high in both available P and K and no response was expected. At the other location, depth of soil complicated results.

The results indicate that our soil test recommendations for pastures are about right, assuming this soil is a representative one.

Title: POTASSIUM FERTILIZATION OF ALFALFA SEEDINGS

Leader: C. S. Brown, Maine

Studies were continued during the 1967 season with seedings of Saranac-Pennlate made with and without an oats companion crop. Two locations, representing extreme levels in available soil potassium, were selected for the seedings. On the low K soil (Bangor silt loam--85 lb available K) potassium fertilization increased the yields of alfalfa nearly 1 ton dry matter and had little effect on orchardgrass. On the high K soil (Hadley silt loam--266 lb available K) potassium applications had only a small beneficial effect on alfalfa yields. Total forage yields were increased over 1 ton per acre by the inclusion of oats on the Hadley soil. Oats suppressed orchardgrass but had little effect on alfalfa. A striking effect of oats was the suppression of annual weedy grasses in the second harvest. Alfalfa stands were actually improved by this weed control effect of the oats.

Title: COMPANION CROP EFFECTS ON ALFALFA SEEDINGS

Leader: C. S. Brown, Maine

Studies were continued during the 1967 season to evaluate the effects of oats and sudangrass as companion crops to alfalfa-bromegrass seedings. The comparative responses of Cayuga, Narragansett, and Saranac alfalfa were determined. Total yields of weed-free forage were increased about one-half ton dry matter by oats, while sudangrass had relatively little net effect. Alfalfa yields were suppressed about equally by the two companion crops, although oats were competitive in early season while sudangrass exerted its effect chiefly following the first harvest in mid-July. Bromegrass yields were decreased more by the inclusion of oats than by sudan.

Little differences between alfalfa varieties were noted in the absence of a companion crop. The Saranac variety proved superior when either companion crop was used. Excellent stands of all three varieties were established, regardless of companion crop, in response to the high soil fertility level of the experiment.

Title: RELATION OF SOIL FERTILITY TO CROP ESTABLISHMENT AND PRODUCTIVITY

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

Corn plots (1966 Report, p. 68) were established for the third season on Panton clay soil in West Addison, Vermont. Again, rates of N of 100 to 200 lb per acre depressed the growth of corn while applications of manure gave significant increases in yields. Density and moisture measurements of the soil in the treatments gave no clue as to the beneficial effects of manure. However, analyses of soils and plants indicate that the effects of N and manure on the growth of the corn are related to the degree of availability of P and K.

Title: FACTORS THAT INFLUENCE ALFALFA SURVIVAL ON SLOPING FRAGIPAN SOILS OF THE NORTHEAST

Leaders: G. R.Benoit and J. Bornstein, Vermont (in cooperation with USDA)

Cabot silt loam, a sloping hardpan wet soil, is typical of thousands of acres of farm land in the Northeast. Such soil is not normally suitable for alfalfa production or production of many of the other more efficient dairy food crops. The suitability of the Cabot soil for forage and crop production can be increased by proper drainage practices. Thus a 12-plot surface-subsurface drainage research project has been established on the Cabot soil.

The 12 plots in the drainage project have been seeded to Narragansett alfalfa as a drainage indicator crop and these plots are ideal for the study of the factors that influence alfalfa survival on wet, poorly drained northern soils. To date a positive correlation (r = .79-.84, with r at 1% = .515) has been found between the percentage winterkill of alfalfa and the soil water content. If the soil water content in the fall and spring can be lowered to a tension of 0.1 bar, winterkill will be negligible. There is a negative relation between the incidence of alfalfa crown rot and yield. There is a negative correlation (r = -.99; r at 1% = -.87) between the incidence of crown rot and the mean annual amount of water being drained from the plots. The greater the amount of water removed the lower is the incidence of crown rot after drainage. (See List of Publications.)

Title: PRODUCTIVITY AND QUALITY OF FERTILIZED PERENNIAL FORAGES

Leader: L. F. Marriott, Pennsylvania

Applications of up to a total of 120 pounds of nitrogen per acre on established alfalfa stands did not increase yields.

In the second hay year, when smooth bromegrass was fertilized with N, P, K and Mg, only N produced yield increases, with an advantage for split applications because of good moisture distribution. Only one harvest was made in dry 1966 (1966 Report, p. 66).

Application of limestone (calcitic and dolomitic) and Alcan magnesia (not water soluble) in Indiana County, 1966, resulted in an increase in soil Ca and/or Mg generally related to the amount of Ca or Mg applied. Analyses of some of the 1967 plant samples also show this relationship. Other plant samples yet to be analyzed include sudax, alfalfa, grass, corn leaves and oat grain.

Title: THE DYNAMICS OF WATER IN SOILS IN RELATION TO ESTIMATES OF PLANT AND SOIL PARAMETERS

Leader: L. T. Kardos, Pennsylvania

The past year was devoted to reestablishing an experimental area for use in determining the effect of three levels of soil water management on utilization of water by hay-managed swards of single species composition. The plots include alfalfa, birdsfoot trefoil, orchardgrass and smooth bromegrass. Plot size and arrangement were designed to allow more practical use of plastic canopies in order to ensure an annual occurrence of three levels of water stress. The plots were treated uniformly (waterwise) in 1967 during the establishment year. Plots have been instrumented with neutron access tubes to a depth of five feet and with two-tube gamma radiation systems (Troxler Model 1376 with pulse height analyzer). The latter will be used to evaluate moisture content changes in depth increments of 1 to 2 inches, particularly in the upper three feet of soil where sharp gradients in water content over depth have been observed.

Data obtained during the 1962 and 1963 season, in being prepared for publication, are reevaluated in terms of water use efficiency (centiments of H_2O used per 1000 kg of dry matter produced per hectare). These data indicate the following:

1. Ladino and ladino-orchardgrass (pasture-managed swards) were much less efficient in water usage than the eight hay-managed swards (alfalfa, alfalfa-orchardgrass, alfalfa-bromegrass, birdsfoot trefoil, trefoil-orchardgrass, trefoil bromegrass, orchardgrass, bromegrass) under all conditions.

2. The water use efficiency was highest for the first cutting with all ten swards.

3. The alfalfa-containing swards were generally the most efficient at all water management levels but particularly so in the unirrigated treatment.

4. Swards of low productivity were generally least efficient.

Title: REACTION OF ALFALFA AND TREFOIL TO HERBICIDES

Leaders: D. Linscott and R. Seaney, New York

The purpose of these experiments was to study reaction of alfalfa and trefoil varieties to herbicides, EPTC, DNBP, and 2,4-DB. Cayuga, Saranac, Iroquois, Mark II, Empire, and Viking were planted at two locations in 1967. Herbicides were applied to all varieties at slightly higher concentrations than recommended. Data were taken on stand, plant height, foliar damage, and forage yield.

EPTC was the best weed control chemical in these trials and was the least harmful to either trefoil or alfalfa. Superior control of annual grass weeds and acceptable control of nutsedge and quackgrass were obtained. Annual broadleaved weed control by EPTC treatment was almost equivalent to the 2,4-DB or DNBP treatment. Total legume yield (two cuttings) was superior in EPTC-treated plots, with the best variety yielding about 0.5 tons per acre more than the next best herbicide plots (2,4-DB). Stand was not reduced by EPTC treatments.

The postemergence treatment with 2,4-DB controlled broadleaved weeds and did not affect legume stand significantly. However, because of grass competition and some chronic herbicide effects, yields of legume (2 cuttings) were somewhat less compared with the EPTC treated plots. Neither 2,4-DB or DNBP controlled grass weeds. DNBP reduced the stand of alfalfa by 2/3 and the yield by 5/8; it reduced the stand and yield of birdsfoot trefoil by 5/6 and 9/10, respectively. High temperature at time of treatment was responsible for this severe damage.

Saranac was the superior variety from standpoint of yield and reaction to herbicides. Viking trefoil was superior to Empire on the same basis. However, when weed competition was removed the difference between Viking and Empire yields was decreased.

Title: BRUSH CONTROL IN PASTURES

Leader: Collins Veatch, West Virginia

Applications of brush-killer (2,4-D and 2,4,5-T) were made at rates of 2, 4, and 8 pounds of active ingredient per acre by helicopter in June 1966 to several hundred acres of pasture containing various species of brush (1966 Report, p. 73). The 8-lb rate was used only on an old well established stand of Hawthorn (Crataegus spp.) and there was some resprouting in 1967. The 2 and 4 lb rates defoliated and reduced the stands of susceptible species, opening up many areas to grass production. Resistant species such as oak, hickory, and maple will probably require basal spraying or injection treatments. The best control of Hawthorn was secured where the herbicide D & T was applied with a mist blower. Other field tests indicate that Tordon is quite effective on species resistant to the above two herbicides D & T but it has not been cleared for use in pastures.

Herbicides or brush killers should be considered as another tool to aid in the control of brush. Adequate brush control in pastures will require the intelligent use of chemicals, mechanical methods, fertilization, and proper management of grazing.

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, USDA

Results of experiments to determine the modulus of elasticity of alfalfa stalks showed uniform fiber strength from bottom to top of the plants. Average moduli of 2.34 and 15.66 x 10^9 dynes/cm^2 were recorded for stalks in the wet and dry states, respectively. Frequency of vibration of alfalfa stalks tested as a cantilever beam 8 in. long ranged from 20 to 30 cycles per second. The modulus of elasticity for the epidermis of corn at 75% moisture content averaged 10 x 10^{10} dynes/cm^2 and increased to 25 x 10^{10} dynes cm^2 for specimens at 7% moisture content.

Drying experiments were conducted on alfalfa at dry bulb temperatures of 130, 170 and 210 F, dewpoint temperatures of 63, 84 and 104 F and infrared radiation intensities of 0, 750 and 1200 Btu/ft^2-hr. to evaluate constants and to test the drying prediction equation. Results appear to be consistent with theory.

Fluidization drying of forage requires a process state design which permits the continuous upward movement of biological particles as they lose moisture

to the cocurrent drying media. These requirements specify a negatively divergent velocity field. Cooling of the drying gas produces this desired effect but is offset by the release of water vapor. Quantitative results indicate a positive divergence in a constant cross section stage leading to the conclusion that a divergent tower state, larger at top, is required. Such a tower has been designed.

Results of laboratory tests on rye silage show that ultimate strength in tension is related to density and varies with moisture content. The coefficient of friction for silage below 50 lb/ft and 62 percent moisture, due to Coulomb friction, was 0.40.

Modifications were made on the multiple baffle and the 16 ft diameter wheel silos. An initial load of 50 tons on the center cone of the 14 ft diameter silo was recorded with a wheel moment of 90,000 in.-lbs. Plan No. 119 of a self-feeder hay barn has been placed in the New Jersey Building Plan Service. A complete dairy cattle system incorporating free stalls and liquid manure handling based on an 18 ft diameter self-feeding silo has been designed.

Deformation and density properties of chopped alfalfa, sorghum-sudan hybrids and corn were investigated under a sustained pressure of 20 psi. Moisture contents of 70, 40 and 0 percent and 1/8, 1/4 and 1/2 inch lengths of cuts were involved with hold times of 20 to 30 minutes in a test chamber 5.75 in. diameter by 8 in. deep. Bulk density and dry density for the three forages were not affected by particle length. Dry density was significantly influenced by moisture content. Low moisture forage produced low dry matter density and 40 percent material produced a dry density higher than 70 per cent for all forages.

Temperature sensitive paper indicators introduced into the wafers were found to be pressure sensitive and, therefore, not usable. Thermocouples installed in a TEE-glass die just under the hay-die interface, indicated temperatures as high as 130 F and varied with wafering pressure. Hemitorrid ram faces caused the wafer arch to break toward the direction of travel, while concave ram faces caused the arch to break in the reverse direction. Stainless steel and teflon TEE-"S" plated on steel dies have been constructed.

Comparisons were made to determine the relationship between the length of preheating (spontaneous heating) time before drying started and the temperatures reached. It appears that the temperature rise during preheating is not proportional to the length of the preheating time only, but that the initial moisture content has some influence. Preheating in orchardgrass does not retard the drying process as much as in alfalfa and other legumes.

Results of pelleting experiments show that irrigation has no significant effect on the processing characteristics of Coastal bermudagrass. Bahia grass pellets were more dense and had a higher durability index than Coastal bermudagrass but required more energy to dehydrate. Dwarf millet required less energy to dehydrate, the pellets produced better gains and showed poorer physical characteristics than the tall millet variety.

USEFULNESS OF FINDINGS:

Results obtained show much promise of providing the necessary input information to the successful development of prediction equations for drying forages in batch and in continuous flow dehydration processes. Studies of the mechanical properties, viscoelastic behavior, mass flow characteristics and pelleting and wafering properties of forages provide the essential information for deliberate design of harvesting, processing and handling systems.

Next year similitude studies to model the fluidization process stage designs using chemically active particles to simulate water vapor release from forage particles will be undertaken. A continous flow dryer will be constructed and tested. Compression studies of green and ensiled alfalfa and corn will include relaxation and expansion properties. Creep and relaxation tests will be performed on wafers. Feeding trials will be conducted using various forages and forms including pellets and wafers to determine the nutritive value as affected by processing.

Title: QUANTITATIVE DETERMINATION OF HEAT AND MASS TRANSFER COEFFICIENTS

Leader: R. J. Rowe, Maine

A planned series of 135 thin-layer drying tests of chopped forage were completed. Data from these tests were used to calculate separate heat and mass transfer coefficients for alfalfa. Work is continuing on a statistical analysis to indicate the extent of dependence of these coefficients on air and plant temperatures.

Work on the application of these data to design a continuous flow forage dryer was initiated in 1967. A computer simulation of a parallel flow dryer has been developed and plans are being formulated for experimental work in this area.

Title: APPLICATION OF ENERGY FOR CONTROL OF INSECTS

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

Due to the relatively slow application speed (2 mph) and fuel consumption rate (approx. 40 gallons per acre) required for effective control in 1966, major emphasis was placed on equipment development and evaluation (1966 Report, p. 39). The specific objectives were to determine the relative effectiveness of three field flamers and the combined effects of a herbicide treatment and a flaming treatment on the alfalfa weevil and weeds. The results indicated that 2 treatments were required for full season

protection. A dormant flame treatment at speeds of 3 mph with flamers equipped with hoods was equivalent to a foliar insecticide application. In each case an additional application of insecticide was needed to obtain the same yield. The use of a herbicide to precondition plots prior to a flame treatment gave excellent weed control and increased weevil control slightly but not significantly. Progress was made in the development of a field flamer. The results obtained with the experimental flamers at 3 mph indicated an effectiveness equivalent to the control obtained with the flamer in 1966 at a speed of 2 mph.

Section IV

Growth, Physiology, Biochemistry, Root Reserves, etc.

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

Leader: W. G. Colby, 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 present project outline embraces three objectives:

1. To determine the effects of management and environment on the morphological development and growth rate of perennial forage grasses.

2. To study factors influencing the accumulation and depletion of food reserves in perennial forage grasses.

3. To establish the nutritional value of forage samples representative of specific management systems.

Accomplishments under these objectives were:

Objective 1.--Field experiments were carried on in Pennsylvania on the effect of nitrogen fertilization and cutting height on the growth and dry matter yields of reed canarygrass. Nitrogen fertilization greatly increased forage yields, promoted tiller development especially in the spring and early autumn, and increased the height of plant and also growing point. Cutting at 1-1/2 inch height instead of 3-1/2 resulted in higher dry matter yields, significant increase in tiller number, and a small but significant increase in root weight.

Work was continued at Maryland with temperature controlled plots. Soil temperature had a significant influence on plant height, tiller number, dry matter yield, and crown and root weight. In general, yields were highest for all three grasses at 10 C, followed in turn by ambient temperature, 21 C and then 32 C. The same general pattern was found for tiller crown growth, and root growth. Climax timothy was most sensitive to soil temperature, followed by S-37 and then Potomac orchardgrass.

An environmental growth chamber experiment was conducted in West Virginia using timothy, smooth bromegrass, orchardgrass and Kentucky bluegrass. A period as short as 3 hours at 95 F out of a 15-hour day resulted in yield decreases of as much as 33 percent for timothy, bromegrass and bluegrass. In the case of orchardgrass, yields were reduced by only 19 percent. Extending the period of exposure at 95 F gave further gradual yield decreases for all species.

Objective 2.--Work on seasonal fluctuation in carbohydrate reserves in timothy was carried on at Rhode Island and Massachusetts. Both stations studied the effect of nitrogen fertilization on reserve carbohydrate levels. Massachusetts also included a time of harvest variable. In both experiments nitrogen depressed levels of carbohydrate reserves although to a much greater extent at Amherst than at Kingston. This occurred even though the maximum rate of nitrogen applied at Rhode Island (252 kg/ha) was substantially higher than the 150 lb/A rate applied at Massachusetts. Cooler growing conditions at Rhode Island, especially during the critical month of June, is part of the explanation. (The average June temperature at Kingston was 5 F lower than it was at Amherst.)

During the period of rapid growth at Amherst (May 20 to June 20) carbohydrate reserves fell to quite low levels especially at high rates of nitrogen. Soon after rapid growth ceased, carbohydrate levels rose rapidly on all plots. It appears (1) that during periods of rapid growth, photosynthetic energy may not meet the plant's energy needs so it draws on its carbohydrate reserves; (2) that as soon as rapid growth ceases and its total energy needs are reduced, carbohydrate reserves are quickly restored; and (3) that nitrogen fertilization increases the growth rate and in so doing may cause the depletion of carbohydrate reserves.

Recovery growth for all cuttings made during the period of rapid growth was very poor for the two high nitrogen treatments (90 and 150 lb N/A) and not more than 50 percent recovery on the 60 lb N/A treatment cut at the 15 to 18 in. tall and early heading growth stages. Timothy produces relatively few nonflowering tillers. Recovery growth must primarily be made through

the initiation and development of new tillers. It appears that if reserve carbohydrate levels are low and if photosynthetic energy supplies are cut off through removal of practically all of the leaves as harvested forage, new tiller formation does not take place.

Objective 3.--Vermont and Maine continued to supply forage from variously managed timothy plots to NE-24 Cooperators for nutritional studies.

USEFULNESS OF FINDINGS:

Research carried on this past year at cooperating stations has been concentrated on the influence of specific management practices (Pennsylvania), environmental factors (Maryland and West Virginia), and certain plant constituents (Massachusetts and Rhode Island). Work of this nature is basic to an understanding of how plants respond in relation to environment and management. First, it may help to explain poor crop performance with certain management practices, i.e., early cutting of heavily fertilized timothy in warm season areas. Second, if the causal factors for poor crop performance are known, more suitable management practices can be followed, i.e., if a timothy stand is heavily fertilized, delay harvest until after the full head stage or later. We are at last beginning to find "handles" for studying forage crop management practices and problems.

Title: SEASONAL VARIATIONS IN CARBOHYDRATE RESERVES IN TIMOTHY AND THEIR CAUSES

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

Results from work this past season on carbohydrate reserves (CHO) in timothy were most productive. We believe that we not only have a clearer picture of the role of reserve CHO in the timothy plant but also a better concept of some of the factors which influence the level of CHO reserve. These same factors appear to apply to other cool season grasses as well.

This past season we added a stage of growth cutting variable to a rate of N variable (1966 Report, p. 40). Seven harvests were made, beginning on June 5 when plants were 8" to 10" high and extending to August 2 at the mature seed stage. Because of an abnormally cool spring, plant growth was considerably delayed. Active growth did not begin until about May 26 but it continued at a rapid rate until full head stage was reached about June 26. From this date on there was little increase in total dry matter. At the high rates of N there was actually a loss in dry matter yields due to lodging. Table 4 gives the growth rate for 5 periods.

Table 4. Average daily growth rate of Climax timothy at different rates of nitrogen fertilization (lbs N/A). Amherst, Mass. 1967.

Growth periods	Average growth rate per day (lbs/A)				
	None	30 lbs	60 lbs	90 lbs	150 lbs
May 26-June 5 (A)*	70	132	219	285	308
June 6-June 12 (B)*	83	260	285	250	261
June 13-June 19 (C)*	90	256	278	313	321
June 20-June 26 (D)*	2	10	35	86	63
June 27-July 6 (E)*	0	2	5	-25	-85

* (A-E) - Growth stages at harvest.

Because of the very cool weather throughout most of May 1967, CHO in all plots fertilized in the fall or early spring rose to high levels. When rapid plant growth did begin, CHO levels began to fall. These levels declined progressively for each added increment of N. At the high rates of N, CHO fell to very low levels. As soon as rapid growth ceased, CHO levels for all treatments rose very rapidly to uniformly high levels. The obvious conclusion seems to be that during this period of rapid growth, the energy supply from photosynthesis was inadequate to meet the energy requirements of the plants. Hence, they were forced to draw on CHO to meet their energy needs; and, the faster the growth rate, the greater the depletion of CHO. When dry matter production ceased, the total energy requirements of the plant fell drastically. The plant therefore, was able to replenish CHO rapidly and the levels rose sharply.

We suggest the following explanation for the stand recovery data (Table 5). Most primary timothy tillers bear seed heads. When plants are cut below the primordia, regeneration must take place by means of new or secondary tillers. Japanese work (Tanaka, A. and Garica, C. V. Soil Sci. and Plant Nutr. 11 (3): 31-37, 1965) has shown that ample supplies of reserve energy and of available N are necessary for the initiation of new tillers. If the energy supply is inadequate, secondary tillers do not develop. During the period of very rapid growth available N was adequate but the levels of CHO were too low in plants on the 150, 90, and, to some extent, 60 lb N plots for the initiation and development of secondary tillers. Since there were very few nonflowering primary tillers, most of the plants on the high N treatments withered and died for lack of tiller growth a short time following the harvest. Harvesting removed practically all of the leaf and stem surface so there was very little photosynthetic energy available. Without an adequate source of photosynthetic energy and with CHO levels too low in basal stem tissue to facilitate the formation of secondary tillers, stands on all but the low N plots of the early cuttings were either severely

injured or lost altogether. It is obvious that, with timothy, early cutting and heavy N fertilization are not compatible in climates similar to Amherst or warmer.

Table 5. Recovery of timothy harvested at different growth stages and fertilized with different rates of nitrogen (lbs N/A). Amherst, Mass. 1967.

Stage of growth at harvest	Percent of full stand			
	30 lbs N	60 lbs N	90 lbs N	150 lbs N
Plant height 8"-10" (A)	100	100	90	20
Plant height 15"-18" (B)	100	50	10	5
Early head (C)	100	50	10	5
Full head (D)	100	100	90*	75*
Full bloom (E)	100	100	90*	75*

* Lodging injury.

There appears to be a simple basic relationship within the plant between the photosynthetic energy and CHO energy on the one hand and the total energy required by the plant for growth and respiration on the other. The plant normally relies on photosynthesis to supply its energy needs. If the energy requirements for these needs are less than that supplied through photosynthesis, levels of CHO increase. If energy requirements for growth and respiration exceed the photosynthetic energy supply, the plant utilizes CHO to make up the deficit. Consequently, CHO level declines. If CHO levels are reduced to critically low levels, especially if much of the leaf surface is removed by harvesting, many plants may fail to recover and the stand suffers severe injury. Tall growing forage grasses like timothy are especially susceptible to serious injury and even complete loss of stand if harvested when CHO levels are very low at the time of harvest.

Title: ENVIRONMENTAL STUDIES ON RED CLOVER IN RELATION TO INTERNAL BREAKDOWN

Leaders: V. G. Sprague and K. E. Zeiders, Pasture Laboratory

Further studies were made in the greenhouse on relation of environmental factors to internal breakdown (IB) of red clover (see 1965 Annual Report, p.9). Plants were grown for 6 months at 60° and 80°, at 11- and 16-hour photoperiods, and with 1-month and 3-month cutting frequencies. Yields of

tops were taken, and at the end of the 6 months the plants were examined for root diameters, the incidence of IB, and the area of the browning. Total yields of tops for the 6 months were greater under the 3-month cutting regime than when the plants were cut every month. Root diameters and amounts of IB were greater at 60° than at 80°. Some significant correlation coefficients were obtained between top yields and root diameter ($r = 0.76$ at 60° and 0.97 at 80°), between yield and areas of IB ($r = 0.73$ at 60° and 0.81 at 80°), and between root diameter and areas of IB ($r = 0.75$ at each temperature). The overall effect of daylength was not significant. It is concluded that the growing conditions which produced plants with the highest yield of tops and the largest root diameters also contributed to IB, both as to incidence and area of browning. It is suggested that if selection of IB-free plants is attempted the plants should be grown under conditions favorable to its development, which are less frequent cutting and at 60° rather than at 80°.

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

Leader: M. J. Wright, New York

Recent work on this project (1966 Annual Report, p. 56) has been concentrated on the mechanisms that govern the accumulation of nitrate in plants. The present hypothesis, developed by F. W. Smith under the direction of J. F. Thompson, USDA, is that the enzyme (nitrate reductase) that controls the conversion of nitrate to amino nitrogen is the governor of assimilation. The synthesis of this enzyme is believed to be regulated by a substance or substances containing amino nitrogen; in short, a feedback mechanism is assumed.

Title: MORPHOLOGICAL AND PHYSIOLOGICAL RESPONSES OF PERENNIAL FORAGE GRASSES

Leader: M. J. Wright, New York

Reported by title only (see 1966 Report, p. 55).

Section V

Utilization, Digestion Trials, Hay, Silage, etc.

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

Results from studies by participating stations confirm previous years' findings that delay of harvest significantly affected the composition and nutritive value of forages. Crude protein decreased, crude fiber increased and digestibility decreased from 0.3 to 0.5 percentage units per day as harvest was delayed after the first week of June. Nutritive values of crownvetch reported by two stations gave conflicting results. These trials will be continued.

Maximum voluntary intake measured with cattle and sheep, in general, followed digestibility in that the more digestible the forage the more acceptable it was to the animal.

Studies of different rates of nitrogen, phosphorus and trace mineral fertilization were made at some of the stations during the year.

Studies on the effect of different levels of intake (maintenance and ad lib.) on the nutritive value of the forage showed no significant differences between levels.

Net energy, measured as stored energy by the comparative slaughter method and by respiration chamber calorimetry, further emphasized the importance of early harvesting to obtain the greatest nutritive value of the forage.

Metabolic weight expressed as $wt^{0.54}$ was found by workers at the New Jersey station to be an effective reference base for equating feed capacity on ad lib. level of intake in young cattle. Similarly the New York station reported that using the 0.84 power of body weight reduced variation in intake of DM by steers and wethers.

USEFULNESS OF FINDINGS:

Data accumulated from all participating stations in the area on the relationships of date of cutting or stage of maturity to the nutritive value of forages will serve as the basis for recommending management practices. Prediction equations, based on chemical composition of forages, are constantly being developed, and these predicted values are being compared with those determined by intake, digestibility and utilization trials.

Title: THE NUTRITIVE EVALUATION OF FORAGES

Leaders: J. G. Welch, J. L. Evans, and C. Karue, New Jersey

Net energy for production (NEp) was determined in three stages of maturity of orchardgrass hay, cut on May 20, May 30, and June 9. The comparative slaughter method was used utilizing a total of 42 wethers. The NEp of the May 20 and May 30 hays were 462 and 230 kcal/kg., respectively. The June 9 stage had an estimated NEp of 0 in this trial due to poor consumption resulting in no growth. Attempts were made to make hypothalmis lesions in sheep with bipiperidyl mustard. Doses of the same preparation which caused obesity in female ICR mice proved toxic to sheep. Lower doses (10 mg/kg.) produced immediate toxic symptoms followed by a decrease in feed intake in wethers. Bipiperidyl mustard had no effect in increasing the feed intake of male ICR mice. Urea solutions sprayed on straw increased the voluntary intake and the spraying of the straw was more effective in promoting N retention than was placing urea in a concentrate mixture (see List of Publications).

Title: THE NUTRITIVE EVALUATION OF FORAGES

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

Objectives were to study chemical properties of the plant and the physiological status of the ruminant animal which control the intake and utilization of forage crops. The ad libitum intake by growing steers of 16 orchardgrass and 1 alfalfa forage harvested throughout 1964 and 1965 involved 109 observations (67 individual, 42 cafeteria). The 0.54 power-of-body-weight was a more effective reference base of equating feed or gut capacity to body weight for growing steers (147-488 kg) than was the 0.75 power which is used for mature animals. With an average of 59% cell-wall constituent (CWC) in forage dry matter, the 0.54 power reference unit gave an intake of 297 grams; the 0.75 power, 91 grams. Ingestion choices (cafeteria studies) of orchardgrasses were inversely related to harvest dates or regrowth interval for both first and aftermath forages. First growth alfalfa was selected over all orchardgrasses. With individual

intake studies, first harvests were ingested at slower rates than aftermaths; alfalfa ingestion was larger than for any grass. As date-of-harvest was delayed, consumption declined. The body weight of the growing animal and the percent CWC of the forage explained 70% of the variation in dry matter intake (DMI) and digestible DMI. Body weight alone accounted for 59 and 52% of variation in DMI and digestible DMI, respectively. Components of CWC accounted for variation in DMI and digestible DMI as follows: hemicellulose, 6 and 12%; cellulose, 4 and 6%; and lignin, 1 and 0%, respectively. (See List of Publications.)

Title: THE NUTRITIVE VALUE OF REED CANARYGRASS

Leaders: N. F. Colovos and J. B. Holter, New Hampshire

Hay from a stand of reed canarygrass, harvested at different stages of maturity, was evaluated during the past two growing seasons by means of forty-four complete energy and protein digestion and utilization balances with two groups of four steers in a 4 x 4 Latin square design.

The nutritive value was determined at two levels of nutrition, ad lib and maintenance. The heat production and daily balance of energy on each level of nutrition were measured by means of an indirect open-circuit calorimeter. The acceptability of the hays was determined with both steers and adult wethers.

The results of the experiment show that the nutritive value on the basis of TDN, digestible protein, digestible energy, metabolizable energy or net energy decreases with delay in first cutting, digestible protein and net energy changes being more pronounced. The acceptability rate of the forages by both steers and wethers followed that of the digestibility of dry matter. The comparative yields of nutrients per acre were higher when the forage was cut early. The megacalories of net energy and kilograms of digestible protein per acre were higher in the early cutting than in the late cutting even though the dry matter yield was higher in the latter.

Title: LACTATION STUDIES ON THE EFFECTS OF CORN SILAGE AND ALFALFA HAY AND ENERGY LEVELS ON MILK PRODUCTION AND COMPOSITION AND THE PHYSIOLOGY OF COWS

Leaders: J. H. Vandersall and R. W. Hemken, Maryland

In a three-lactation study cows fed corn silage as their sole forage produced as well as those that received half of their forage dry matter from alfalfa hay and half from corn silage (1966 Report, p. 36). Also those fed limited forage (0.9 lb/100 lb body weight) produced as much milk, but during the first two years the fat percent of the milk they produced was lower. This

was not true during the third year. Under conditions of the experiment, the cows being offered 140% of Morrison's ENE Standards for milk production did not eat all of their allowance during the first part of lactation. In some cases this was also true for the cows offered 125% of these allowances. Milk production generally followed actual feed consumption so the differences between the energy levels allowed were inconsistent. When the forage is supplemented with high levels of concentrates, the feeding of corn silage as the only forage did not alter the quality of the milk as measured by protein, solids-non-fat, and fat percents, nor in the percent of the fatty acids with a carbon chain length over 12. In a second trial, concentrate to silage dry matter ratios of 3:1, 1:1 and 1:3 were fed. An additional group was fed 1/2 of their dry matter as pellets made from dehydrated whole corn plants. The quantity and composition of the milk produced by this group was satisfactory. When these pellets composed the total forage allowance, the fat percent of the milk was depressed. Statistical analyses of these data are nearing completion.

Title: COMPARISON OF PEARL MILLET AND SUDANGRASS AS FORAGE FOR LACTATING DAIRY COWS

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

This study is a continuation of work which has established that pearl millet, especially when grown under high lime and K fertilization, depresses butterfat in dairy cows while sudangrass does not (1966 Report, p. 36). This was observed in 1966 and again in 1967. Laboratory work in 1967 also shows that forages associated with fat depression were higher in oxalic acid and nitrate than forages not responsible for fat depression.

Title: THE EFFECTIVE USE OF BLUEGRASS-WHITE CLOVER PASTURES

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

Exposure is a major factor influencing the productivity of hill pastures. The following results obtained during the 1967 grazing season illustrate this:

	Exposure	
	North	South
No. steers	18	18
Grazing days	86.6	132
Total gain per steer	128.7	201
Steer gain per day	1.49	1.52
Steer gains per acre	275.7	430.5

The pastures are 1.4 acres and stocked with 3 steers weighing about 650 lb. The pattern of grazing was influenced by exposure, but no significant effect upon distribution of activity was apparent. The total time devoted to grazing was inversely related to herbage (dry matter) availability.

The pure grass swards (2.1 acres) in association with the above hill pastures contributed 33 grazing days/acre to the system. In addition to the grazing days, the following quantities of 85% dry matter forage were harvested: orchardgrass, 9808 lb/A; bluegrass, 7729 lb/A; and tall fescue, 10123 lb/A. The seasonal distribution of the harvested forage was as follows:

Species	1st cut	2nd cut	3rd cut
	%	%	%
Orchardgrass	47	31	22
Bluegrass	48	23	29
Tall fescue	50	21	29

The harvest or cutting dates were June 6, July 10, and August 23.

Title: SOIL-PLANT-ANIMAL INTERRELATIONSHIPS IN PHOSPHORUS METABOLISM

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

Digestibility and intake studies have been completed on timothy hays harvested in mid-June of 1965 and 1966 from forage plots representing a low level and a high level of phosphorus fertilization (1966 Report, p. 32). Average phosphorus concentration of these forages when harvested were essentially the same for both years (low-P, 0.20% and high-P, 0.34%). Winter feeding trials were conducted with sheep to evaluate these forages along with a treatment consisting of the low-P forage supplemented with monosodium phosphate in amounts calculated to increase P intake to a level equal to that on the high-P forage.

Average voluntary intake and digestibility of dry matter and energy values did not vary significantly between years nor among the phosphorus treatments. Digestibility values for crude protein and the fiber fraction were essentially the same among the phosphorus treatments although these did differ significantly between years. Average crude protein concentration of the first year's forage (18.4%) was higher than that for the second year (16.0%). The higher protein concentration of the first year's forage was associated with significantly higher protein digestibility (78.4% vs. 75.4%) and significantly higher fiber digestibility (68.7% vs. 58.6%). Variations in the retention of Ca, P and N were not associated with phosphorus treatments. It was concluded from these studies that fertilization programs which increased the phosphorus concentration of early-cut timothy hay from 0.20% to 0.34% P had no significant effect on its nutritive value for ruminants.

Title: NUTRITIONAL EVALUATION OF FORAGES

Leader: H. Fenner, Massachusetts

During the 1966 growing season four Seal-Vac plastic silos were put up according to the specifications of the manufacturer. Crops used were: first cutting orchardgrass (90% pure, partly in bloom), third cutting wilted alfalfa (some weeds), and fourth cutting alfalfa. They gave good to excellent silages. A third cutting reed canarygrass preserved as baled forage turned out to be a complete loss. Compressing bales by vacuum perforated plastic film. Condensation under the poorly insulating plastic leached the acids from the top layers, subjecting them to spoilage. Molds were the major reason for deterioration. The orchardgrass ensiled during the early part of the season resulted in a mild silage with high pH, high concentrations of C_3-C_6 acids, alcohol, and lactic acid. Lack of an offensive stench and a low proportion of ammonia rated the silage as good. Rapid spoilage mainly by molds occurred after exposure to air. This showed the low stability of this silage which stayed well preserved as long as anaerobic conditions could be maintained. The two alfalfa forages preserved in the fall as haylage and silage resulted in excellent feed, containing high proportions of alcohol, lactic acid, total acids, and a low pH and ammonia content. Dry matter losses determined by the buried bag technique in one silo amounted to 10% (8-12%) of the original forage. In general the nonprotein nitrogen of the forage doubled as a result of the fermentation process. The problem of high susceptibility to spoilage by molds requires further studies. Some compositional data are given in Table 6 for the three good silages.

Title: LEAF-STEM RATIO IN ALFALFA

Leader: J. T. Sullivan, Pasture Laboratory

A high leaf-stem ratio is considered a mark of nutritional quality in alfalfa. Preliminary experiments were carried out in a greenhouse, cooled in warm weather, to determine whether some plants have a tendency to have a higher leaf-stem ratio than others. In one experiment with 30 plants as a starting population, three successive cuttings were made in July, August, and September. The correlation coefficients of the ratios between dates were not significant, though two of the three possible combinations were nearly so. In another group of 30 starting plants (dropping to 23), four cuttings were made, in November, December, January, and February (1968). The leaf-stem ratios in individual plants ranged from .54 to 2.05; the mean ratios for dates ranged from .81 to 1.07. All of the 6 possible correlation coefficients between dates were significant, 3 of them $>.01$. The results suggest that some plants have a tendency to have a higher leaf-stem ratio than others at successive cuttings. This work will be continued in the field.

Table 6. Composition of forages as vacuum silage.

	Orchardgrass		Alfalfa-Weeds (wilted)		Alfalfa-Grass	
Date of harvest:	1st cutting 6/4/67		3rd cutting 10/6/67		4th cutting 10/28/67	
	Green	Silage	Green	Silage	Green	Silage
Date sampling of silage:	-- --	10/20/67 to 11/14/67	-- --	1/31/68 to 3/9/68	-- --	3/27/68 --
Dry matter*	21.2	22.7	42.8	45.0	29.4	31.2
Crude protein	11.3	10.4	20.1	19.1	22.5	22.2
Nonprotein N**	19.1	44.1	23.2	45.2	21.0	52.8
Crude fiber	36.6	40.1	24.3	23.8	18.9	19.3
pH	--	5.06	--	4.41	--	4.40
Total bases	--	0.42	--	0.27	--	0.35
Total acids	--	8.68	--	12.71	--	13.79
Lactic acid	--	2.61	--	11.01	--	11.70
Acetic acid	--	1.73	--	1.70	--	2.09
Propionic acid	--	0.27	--	--	--	--
Iso-butyric acid	--	0.19	--	--	--	--
N-butyric acid	--	2.80	--	0.01	--	--
Iso-valeric acid	--	0.27	--	--	--	--
N-valeric acid	--	0.13	--	--	--	--
N-caproic acid	--	0.70	--	--	--	--
Alcohol	--	1.99	--	0.55	--	1.57

* In % fresh weight.
** In % total N.
All others in % dry matter.

Title: NUTRITIVE VALUE OF LIVESTOCK FEEDS PRESERVED AND STORED AS SILAGE

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

Pennsylvania hybrid 602A corn, Sweet Sioux sorghum-sudan hybrid, Trudan II hybrid sudan, and Piper sudangrass were ensiled for feeding trials with lactating Holstein cows. Highest silage yields were obtained with corn and lowest with Piper sudangrass. The corn produced from 4.29 to 2.71 tons more silage per acre on a dry matter basis than the other summer annuals. The feeding trials with ensilage from these summer annuals have not been completed.

Title: BEEF CATTLE PERFORMANCE AS RELATED TO FORAGE, GENETIC, AND PHYSIOLOGICAL VARIANTS

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

Dry matter yields of 3.28 to 5.87 (avg. 4.53) tons per acre were obtained from pasture swards of orchardgrass, reed canarygrass, and Kentucky bluegrass. These swards received 400 lb per acre of 0-15-20 fertilizer and 100 lb of N applied in split applications of 50 lb each in early spring and midsummer. A mixture of smooth brome, timothy, and orchardgrass averaged 4.0 tons of dry matter with a carrying capacity of 603 cow days per acre. Mountain Kentucky bluegrass or orchardgrass swards averaged 3.19 and 3.04 tons of dry matter per acre and furnished 302 and 328 cow days of grazing per acre, respectively.

Title: PASTURE EVALUATION USING BEEF STEERS

Leader: A. M. Decker, Maryland

Grazing of experimental pastures (sod-seeded rye-wheat in 'Midland' bermudagrass with 200 and 400 lb N/A and test animals with no grain or with 0.7 lb per day per 100 lb body weight) were grazed for the third season (3/26/67 to 11/3/67). Rainfall was above normal throughout most of the growing season except for a short drought in early June and most of the fall starting in early September. As a result of the latter dry period, little grazing was realized from the fall-seeded cereals. In addition, pastures were not utilized at maximum efficiency during much of July and August because too few animals were available to consume the forage at peak quality (50 animals on 16 acres). Beef gains per acre ranged from 498 lb with low N and no grain to 911 lb with high N plus grain. High nitrogen increased production by 125 lb while the added grain resulted in an average increase of 288 lb. Animals with grain graded low choice while those without graded medium good.

Title: COOL TEMPERATURE STORAGE

Leader: M. A. Sprague, New Jersey

During the first week in November replicate lots of forage of approximately 150 lb of freshly cut rye were placed in steel barrels and (1) treated with 100 lb per ton of dry ice and placed in a refrigerator maintained at 35 F, (2) dried slowly in an oven maintained at 80 F to represent hay, or (3) ensiled and thereby allowed to ferment at a temperature of approximately 65 F. Samples were taken of the forage for analysis prior to storage. Storage will continue throughout the winter period until April 1. Determinations will be made of losses during storage of dry matter, protein, hydrolyzable carbohydrates. In previous similar trials cool temperature storage has resulted in losses so small as not to be identifiable. These trials hopefully will compare losses from the same forage preserved by three different methods, hay, silage and cool temperatures.

Title: HARVESTED FORAGE INVESTIGATION

Leader: M. A. Sprague, New Jersey

For the third year (see 1966 Annual Report, p. 46) pure stands of orchardgrass previously treated 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 ensiled in approximately 1 ton lots in plastic bags which were sealed immediately after filling (1) immediately after cutting and directly behind the field chopper, (2) after approximately 5 hours drying in the swath or (3) after from 2 to 4 days drying in the field. The different lots at the time of preservation were approximately 20, 40 and 60% dry matter, respectively. The contents of the 6 silos were sampled, weighed and stored from the end of May until September 1 at which time they were 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. Further, using a Beckman Model D-2 oxygen analyzer, the oxygen content of the atmospheres within the plastic bags was determined at frequent intervals after sealing.

As in previous years, the data suggest the production of water is proportionate to chemical reactions within the forage mass and also that considerable carbohydrate is lost during the drying period in the swath prior to ensiling.

Although the laboratory analysis of all samples is not yet complete the drier materials do not ferment to as low a pH as do the wetter materials. The pH of the low moisture content materials at the time of opening the silos ranged from 4.8 to 5.4 which represented practically no change in the low nitrogen forages which were dried to 60% dry matter.

Laboratory silos of approximately 1,000 gram capacity duplicated each of the field size silos. Sample analysis indicated a close parallel with respect to chemical reactions between the two.

Oxygen content of the atmospheres surrounding the forage was determined at 15 minute intervals after sealing. The oxygen dropped very rapidly from 20.5% to approximately 15% during the first 15 minutes, to 8.5% during the next 15 minutes, and to 1.5% during the next 15 minutes. This rapid exhaustion of oxygen is very significant, and indicates that oxidative processes are very rapid within the forage. This observation also has a bearing upon the value of the use of vacuum as a means of increasing efficiency of preservation since for all practical purposes in the field the oxygen within the forage mass would be completely exhausted before a vacuum pump could be attached. It is concluded that pumping to establish a vacuum, as was previously recommended, serves no useful purpose with respect to exclusion of oxygen as a means of reducing dry matter losses since the oxidative processes within the forage mass itself have already accomplished this.

Title: 1967 "SEAL-VAC" SILO DEMONSTRATION

Leaders: J. B. Holter and N. F. Colovos, New Hampshire

Wisconsin 335A corn, ensiled September 19 at a hard dough stage (unfrosted), was finely chopped and packed into a stack with a wheel tractor. The 109-ton stack (29.7% DM) was sealed and evacuated. The resulting silage (29.3% DM) was fed out in 35 days beginning October 10. Essentially no visible (mold) spoilage was noted and the silage was accepted well by our milking dairy herd. Losses of dry matter, ash, protein, ether extract, fiber and NFE were 23, 31, 18, 8, 24 and 24%, respectively. Despite the dry matter loss, which corresponds to that generally found in small-capacity horizontal silos, an acceptable feed was obtained. The Seal-Vac structure has practical application in cases where corn production temporarily exceeds permanent storage facilities. We acknowledge donation of the structure by the Gering Plastics Co.

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, New York

This project (1966 Annual Report, p. 56) is terminated. Recent work has been on the decomposition of herbicides during ensiling or dehydration, in cooperation with D. L. Linscott, ARS, USDA (see Friedman in List of Publications).

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