

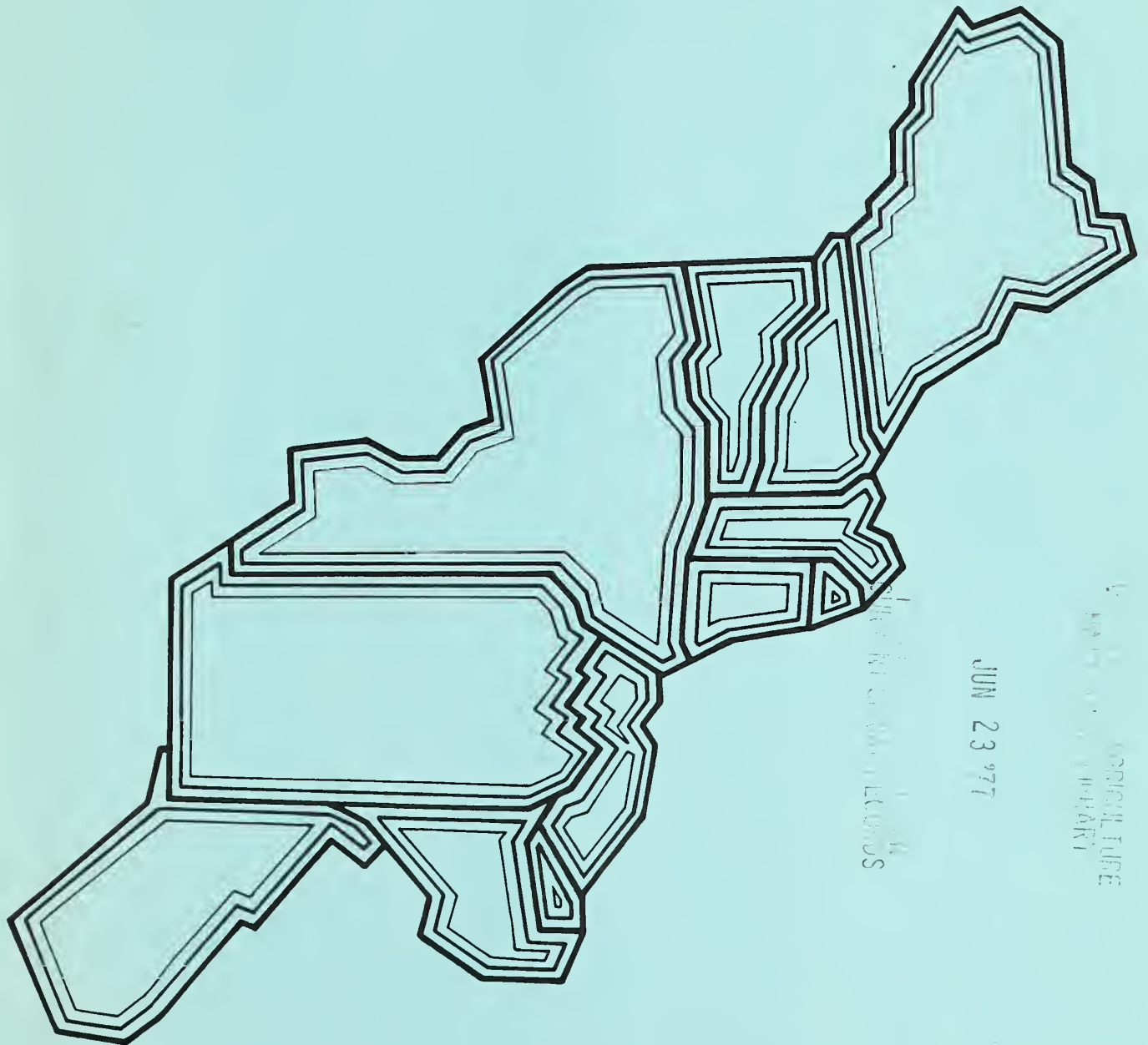
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FORTIETH ANNUAL REPORT OF FORAGE RESEARCH IN THE NORTHEASTERN UNITED STATES,

1976



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Fortieth Annual Report
of
Forage Research
in the
Northeastern United States

A Joint Contribution of the
U.S. Regional Pasture Research Laboratory
and the
Beltsville Agricultural Research Center
and the
Agricultural Experiment Stations
of the Twelve Northeastern States

Participating Agencies

Beltsville Agricultural Research Center
Chesapeake-Potomac Area, and
North Atlantic Area
of the Northeastern Region
Agricultural Research Service, U.S. Department of Agriculture
and the
Agricultural Experiment Stations of

Connecticut (Storrs)
Delaware
Maine
Maryland
Massachusetts
New Hampshire
New Jersey

New York (Cornell)
New York (Geneva)
Pennsylvania
Rhode Island
Vermont
West Virginia

* * * * *

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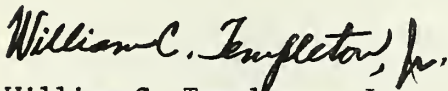
PREFACE

The first Annual Report of Forage Research at the U.S. Regional Pasture Research Laboratory and the twelve cooperating agricultural experiment stations was made 40 years ago. Twenty copies were prepared and distributed.

The fortieth report, of which 500 copies were made, includes over 120 brief summaries of forage and forage-related projects involving work of more than 150 scientists in northeastern United States during 1976. The report is intended, primarily, for use by forage research and extension personnel in northeastern United States. Included are highlights of forage research activities at most of the agricultural experiment stations in the region and those of the Northeastern Region, Agricultural Research Service, and Beltsville Agricultural Research Center, U.S. Department of Agriculture.

Appreciation is extended to the scientists and others whose contributions made the report possible. Special thanks are expressed to Mrs. Victoria Meyer and Mrs. Amina Birkenmayer of the Pasture Laboratory staff, who assembled the original reports, retyped them, and saw the report through to its conclusion.

Continuing support and contributions from forage scientists of the region are solicited and encouraged to make the report as valuable as possible. Suggestions concerning improvement or desirable changes will be appreciated.



William C. Templeton, Jr.
Laboratory Director

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Roster of Research and Extension Workers in the Northeastern
United States with Some Forage Crops and Grasslands Orientation

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Connecticut</u>		
Storrs 06268		
Allinson, D. W.	Forage Management	Plant Science
Cowan, W. A.	Animal Nutrition	Animal Industries
Dest, W. M.	Weed & Turf Invest.	Plant Science
Griffin, G. F.	Soil Fertility	Plant Science
Peters, R. A.	Weed Investigations	Plant Science
Washko, W. W.	Forage Management	Plant Science
Wengel, R. W.	Soil Physics	Plant Science
<u>University of Delaware</u>		
Newark 19711		
Carroll, Robert B.	Plant Pathology	Plant Science
Fowler, R. E.	Beef Cattle Nutrition	Animal Sci. & Agr. Biochemistry
Haelein, G. F. W.	Nutritive Evaluation	do.
Jones, E. R.	Forage Management	Dept of Agriculture Delaware State College, Dover Delaware 19901
Mitchell, W. H.	Forage Management	Plant Science
Reitnour, C. M.	Horse Physiology	Animal Sci. & Agr. Biochemistry
<u>University of Maine</u>		
Orono 04473		
Apgar, W. P.	Forage Utilization	Ani. & Vet. Sci.
Forsythe, H. Y., Jr.	Forage Insects	Entomology
Holyoke, V. H.	Silage Corn Mgt	Plant & Soil Sci
Rowe, R. J.	Engineering Harvesting	Agr. Eng.

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Maryland</u> College Park 20742		
Clark, N. A.	Forage Management	Agronomy
Decker, A. M. Jr.	Forage Management	Agronomy
Leffel, E. C.	Animal Science	Animal Science
Vandersall, J. H.	Dairy Science	Dairy Science
<u>University of Massachusetts</u> Amherst 01002		
Fenner, Heinrich	Animal Nutrition	Vet. & Ani. Sci.
Mudgett, R.	Food & Agr. Eng.	Eng (Food & Agr.)
Vietor, Donald	Plant & Soil Sci.	Plant & Soil S
Whitney, L. F.	Agr. Eng.	Eng (Food & Agr)
<u>University of New Hampshire</u> Durham 03824		
Byers, G. L.	Agr. Eng.	Water Resources Res. Center
Dunn, G. M.	Genetics	Plant Science
Estes, G. O.	Forage Nutrition	Plant Science
Fairchild, T. P.	Animal Nutrition	Animal Science
Frick, G. E.	Agr. Economics	E. R. S.
Holter, J. B.	Animal Nutrition	Animal Science
Koch, D. W.	Forage Plant Phys.	Plant Science
Mitchell, J. R.	Forage Management	Plant Science
Peirce, L. C.	Genet. Hort. Crops	Plant Science
<u>Rutgers University, The State</u> <u>University of New Jersey</u> New Brunswick 08903		
Duell, R. W.	Highway Vegetation	Soils & Crops
Evans, J. L.	Nutritional Value	Animal Science
Halisky, P. M.	Plant Pathology	Plant Biology
Ilnicki, R. D.	Weed Control	Soils & Crops
Mears, D. R.	Agr. Eng.	Engineering
Race, S. R., Jr.	Forage Insects	Entomology & Economic Zoo.

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>Rutgers University (Continued)</u>		
New Brunswick 08903		
Ramage, C. H.	Production Util.	Animal Science
Singley, M. E.	Engineering Util.	Engineering
Sprague, M. A.	Mgt. Preservation	Soils & Crops
Vander Noot, G. W.	Forage Util.	Animal Science
<u>Cornell University (New York)</u>		
Ithaca 14853		
Campbell, J. K.	Agr. Eng.	Agr. Eng.
Duke, W. B.	Weed Control	Agronomy
Fick, G. W.	Forage Phys. & Mgt.	Agronomy
Grunes, D. L.	Soils & Plant Nutr.	U.S. Plant, Soil & Nutr. Lab.*
Helgesen, R. G.	Entomology	Entomology
Linscott, D. L.	Weed Control	Agronomy
Lowe, C. C.	Genetics & Breeding	Plant Breeding & Biometry
Millar, R. L.	Plant Pathology	Plant Pathology
Murphy, R. P.	Genetics & Breeding	Plant Breeding & Biometry
Reid, J. T.	Animal Nutrition	Animal Science
Schaaf, H. M.	Genetics & Breeding	Plant Breeding & Biometry
Seaney, R. R.	Forage Management	Agronomy
Van Soest, P. J.	Animal Nutrition	Animal Science
<u>New York State Agricultural Experiment Station</u>		
Geneva 14456		
Braverman, S. W.	Plant Pathology	Seed Investigation & USDA-ARS do.
Dolan, D. D.	Plant Introduction	USDA-ARS, Ent.
Fiori, B. J.	Entomology	Seed Investigations
Sherring, W. R.	Seed Technologist	

*USDA-ARS Cooperative Appointment

Name	Field of Interest	Department
<u>The Pennsylvania State University</u> University Park 16802		
Ace, D. L.	Dairy Extension	Dairy Science
Adams, R. S.	Dairy Extension	Dairy Science
Bartlett, H. H.	Agr. Eng.	Agr. Eng.
Baumgardt, B. R.	Animal Nutrition	Animal Science
Baylor, J. E.	Pasture & Forage	
	Crops (Extension)	Agronomy Extension
Bloom, J. R.	Nematode Control	Plant Pathology
Burdette, L. A.	Animal Nutrition Ext.	Animal Science
Cash, E. H.	Animal Nutrition	Animal Science
Cleveland, R. W.	Genetics & Breeding	Agronomy
Cowan, R. L.	Animal Nutrition	Animal Science
Downs, W. G.	Forage Management	Agronomy (P.O. Rector)
Dum, S. A.	Farm Mgt Ext.	Economics
Fox, R. H.	Soil Fertility	Agronomy
Guss, S. B.	Vet. Sci. Ext.	Vet. Sci.
Hartwig, N. L.	Weed Control	Agronomy
Hershberger, T. V.	Animal Nutrition	Animal Science
Hower, A. A., Jr.	Forage Insects	Entomology
Johnson, M. W.	Corn Breeding	Agronomy
Kardos, L. T.	Soil Physics	Agronomy
Kesler, E. M.	Dairy Science	Dairy Science
Kjelgaard, W. L.	Agr. Eng.	Agr. Eng.
Knieval, D. P.	Forage Phys.	Agronomy
Kradel, D. C.	Vet. Medicine	Vet. Sci.
Long, T. A.	Animal Nutrition	Animal Science
Lukezic, F. L.	Forage Pathology	Plant Pathology
Marriott, L. F.	Soil Fertility	Agronomy
McKee, G. W.	Ecology, Phys.	Agronomy
Merritt, T. L.	Animal Science	Animal Science
Partenheimer, E.J.	Agr. Econ.	Agr. Econ. & Rural Sociology
Risius, M. L.	Genetics & Breeding	Agronomy
Shenk, J. S.	Forage Grass Breeding	Agronomy
Starling, J. L.	Genetics & Breeding	Agronomy
Thomas, W. I.	Representative NE	Agr. Exp. Sta.
Wangness, P. J.	Animal Nutrition	Animal Science
Washko, J. B.	Forage Management	Agronomy
Wilson, L. L.	Animal Science	Animal Science
Yendol, W. G.	Non-Pesticide Insect Control	Entomology

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>University of Rhode Island</u> Kingston 02881		
Henderson, B. W. Jr.	Animal Nutrition	Animal Science
Wakefield, R. C.	Management	Plant & Soil
<u>University of Vermont</u> Burlington 05401		
Gotlieb, A. R.	Plant Pathology	Botany
MacCollom, G. B.	Entomology	Entomology
Smith, A. M.	Animal Nutrition	Animal Science
Welch, J. G.	Nutritional Value	Animal Science
Wood, G. M.	Forage & Turf Mgt.	Plant & Soil Sci.
<u>West Virginia University</u> Morgantown 26506		
Anderson, G. C.	Animal Nutrition	Ani. & Vet. Sci.
Baker, B. S.	Forage Management	Allegheny Highlands Proj., Elkins, WV
Balasko, J. A.	Forage Phys.	Plant Sciences
Bennett, O. L.	Forage Management	Plant Sciences & USDA-ARS
Butler, Linda	Entomology	Plant Sciences
Diener, R. G.	Agr. Eng.	Resource Mgt.
Elliott, E. S.	Root Diseases	Plant Sciences
Horvath, D. J.	Animal Nutrition	Ani. & Vet. Sci.
Keefer, R. F.	Soil Fertility	Plant Science
Pohlman, G. G.	Soil Fertility	Plant Science (Emeritus)
Reid, R. L.	Animal Nutrition	Ani. & Vet. Sci.
Thomas, R. O.	Dairy Nutrition	Ani. & Vet. Sci.
Toben, G. E.	Agr. Econ.	Resource Mgt.
Ulrich, V.	Plant Breeding	Plant Science
Veatch, Collins	Weed Control	Plant Science (Emeritus)

Name	Field of Interest	Department
Beltsville Agricultural Research Center Northeastern Region, Agricultural Research Service U.S. Department of Agriculture Beltsville, MD 20705		
Adams, J. R.	Entomologist	Insect Path. Lab.
Arminger, W. H.	Agronomist	Biol. Waste Mgt. Lab.
Barnes, R. F.	Forage and Range	Nat. Prog. Staff
Bond, J.	Animal Science	Ruminant Nutr. Lab.
Cantwell, G. E.	Entomologist	Insect Path. Lab.
Carlson, G. E.	Agronomist	Light & Plant Gr. Lab.
Calvert, C. C.	Animal Science	Feed Energy Cons. Lab.
Chatterton, N. J.	Plant Physiol.	Light & Plant Gr. Lab.
Coulson, J. R.	Entomologist	Bene. Insect Intro. Lab.
Dinius, D. A.	Animal Science	Ruminant Nutr. Lab.
Dudley, R. F.	Agr. Eng.	Physical Contr. Lab.
Elgin, J. H., Jr.	Agronomist	Field Crops Lab.
Faust, R. M.	Entomologist	Insect Path. Lab.
Feldmesser, J.	Zoologist	Nematology Lab.
Foote, R. H.	Agr. Admin.	Sys. Entomol. Lab.
Foy, C. D.	Soil Scientist	Plant Stress Lab.
Goering, H. K.	Animal Science	Ruminant Nutr. Lab.
Goodwin, J. S.	Entomologist	Insect Path. Lab.
Graham, J. H.	Plant Path.	Plant Stress Lab.
Heimpel, A. M.	Entomologist	Insect Path. Lab.
Hill, K. R.	Chemist	Ana. Chem. Lab.
Hooven, N. W., Jr.	Animal Scientist	Ani. Oper. Unit
Howell, R. K.	Plant Path.	Air Pollution Lab.
Hyland, H. L.	Botanist	Germplasm Res. Lab.
Keyes, J. E., Jr.	Animal Scientist	Gene. & Mgt. Lab.
Klingman, D. L.	Weed Control	Turfgrass Lab.
Kulik, M. M.	Plant Path.	Seed Quality Lab.
Lentz, P. L.	Botanist	Mycology Lab.
Lindhahl, I. L.	Chemist	Ruminant Nutr. Lab.
Loulouides, S. J.	Entomologist	Insect Path. Lab.
Lynch, G. P.	Animal Scientist	Ruminant Nutr. Lab.
Moe, P. W.	Animal Scientist	Ruminant Nutr. Lab.
Murray, J. J.	Agronomist	Field Crops Lab.
Neal, J. W. Jr.	Entomologist	Field Crops Lab.
Norris, Karl	Laboratory Chief	Instrumentation Lab.
Oakes, A. J.	Agronomist	Germplasm Res. Lab.
Oltjen, R. R.	Animal Scientist	Ruminant Nutr. Lab.
Ostazeski, S. A.	Plant Pathologist	Field Crops Lab.
Owens, L. D.	Plant Physiologist	Plant Nutr. Lab.
Pearson, R. E.	Genet. Animal	Genet. & Mgt. Lab.
Powell, J. B.	Geneticist	Field Crops Lab.

<u>Name</u>	<u>Field of Interest</u>	<u>Department</u>
<u>Beltsville (Continued)</u>		
Ratcliffe, R. H.	Entomologist	Field Crops Lab.
Redfern, R. E.	Entomologist	Bio. Eval. of Chem. Lab.
Reynolds, P. J.	Animal Scientist	Ruminant Nutr. Lab.
Rumsey, T. S.	Animal Scientist	Ruminant Nutr. Lab.
Schechter, M. S.	Chemist	Chem. & Biophys. Con. Lab.
Schroder, R. F.	Entomologist	Bene. Insect Intro. Lab.
Simpson, M. E.	Plant Pathologist	Nutr. Microbio. Lab.
Slyter, L. L.	Chemist	Nutr. Microbio. Lab.
Smith, L. W.	Animal Scientist	Bio. Waste Mgt. Lab.
Terrell, E. E.	Botanist	Plant Taxonomy Lab.
Toole, V. K.	Plant Physiologist	Seed Quality Lab.
Tyrrell, H. F.	Animal Scientist	Ruminant Nutr. Lab.
Vaughn, J. L.	Microbiologist	Insect Path. Lab.
Waldo, D. R.	Animal Scientist	Ruminant Nutr. Lab.
Walker, J. M.	Soil Scientist	Biol. Waste Mgt. Lab.
Wheeler, W. E.	Animal Scientist	Rum. Nutr. Lab.
Yaklich, R. W.	Plant Physiologist	Seed Quality Lab.

U.S. Regional Pasture Research Laboratory
 North Atlantic Area, Northeastern Region
 Agricultural Research Service
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Templeton, W. C., Jr.	Forage Crops Ecology	Laboratory Director
Berg, C. C.	Genetics (Grasses)	
Byers, R. A.	Forage Insects	
Fissel, G. W.	Chemist	
Gross, C. F.	Soil Fertility	
Gustine, D. L.	Biochemistry	
Hill, R. R., Jr.	Genetics (Alfalfa)	
Hite, R. E.	Plant Pathology	
Jung, G. A.	Forage Management	
Kendall, W. A.	Plant Physiology	
Leath, K. T.	Pathology (Legumes)	
Sherwood, R. T.	Pathology (Grasses)	
Zeiders, K. E.	Plant Pathology	

SECTION I

BREEDING, GENETICS, AND PLANT INTRODUCTION RESEARCH

Title: Evaluation of Forage Legume and Forage Grass Introductions at the Regional Plant Introduction Station, Geneva During 1976 Extract from Supplement I to the Annual Report of Regional Project, NE-9 for 1976, Promising Introductions of the 1976 Season

Leaders: D. D. Dolan, S. W. Braverman, B. J. Fiori and W. R. Sherring, New York (Geneva)

Promising Forage Legume Introductions - 1976

1. Alfalfa (Medicago spp.)

The 1976 alfalfa planting consisted of 45 introductions and the 1975 planting carried over consisted of 60 introductions. During 1976, evaluation notes were taken on both plantings as follows: - uniformity, habit, vigor, plant size, crown width, size of stems, leafiness, leaf size, leaf color, time of bloom, time of ripe pods, flower color, pod shape, degree of damage from leafspot, leafhopper and alfalfa weevil, recovery after summer cutting, percentage winter survival and spring recovery.

The following were the most interesting introductions of Medicago sativa in the 1976 planting and should be further evaluated: - P.I. 170445 Tur., 170450 Tur., 174271 Tur., 187004 USA, 188868 Can., 199272-75 Port., 204462 Tur., 204591 Tur., 205198 Tur., 206280 Tur., 206286 Tur., 206287 Tur., 206451 Tur., 206698 Tur., and G-23586 Fr.

The 1975 planting contained the following introductions of Medicago sativa that should be further evaluated: - P.I. 201864 Iran, 199276 Port., 172985 Tur., 182241 Tur., G23168 Can., G-23169 Can., 346908 USSR, and 345647 USSR.

In the 1976 planting the following introductions of Medicago falcata appeared promising and should be further tested: - P.I. 234815 Switz., 314579 USSR, 384507 USSR, G-23582 Ger., G-23583 USSR, G-23584 USSR, G-23170 Can., and G-22269S N.Y.

The 1976 planting also contained one introduction of Medicago aborea, two introductions of Medicago romanica and one introduction of Medicago trautvetteri.

2. Red Clover (Trifolium pratense)

The 1976 red clover planting consisted of 40 introductions. During the interval mid-July to mid-August, each introduction was rated for uniformity, habit, vigor, size of plant, number of stems, size of stems, leafiness, earliness of bloom, number of heads in seed production, susceptibility to

both powdery mildew and virus diseases. In this, the first year of growth, the introductions most promising are: - P.I. 204502 Tur., 221523 Swe., 235852 Swe., 235856 Swe., 237731 Ger., 239700 Switz., and 257274 Swe.

3. White Clover (Trifolium repens)

In the last half of June and up to July 10 evaluation notes were taken on two plantings of white clovers. Each introduction was rated for type, uniformity, vigor, plant size, degree of spread, leafiness, time of bloom, seed set, susceptibility to leafspot, powdery mildew, rust and virus infection. Also, degree of damage due to leafhopper and leaf minor.

The following introductions of white clover in the 1976 planting were the most promising with regard to these characteristics: - P.I. 231784 N. Hamp., 231785 N. Hamp., 231786 N. Hamp., 231789 N. Hamp., 232110 Ger., 232113 Ger., 234680 Fr., 234840 Ger., 234934 Switz., 237732 Ger., 388632 USSR, 250987 Yugo., 297986 Austral., 316352 USSR, 369037 Port., 369038 Czech., and 369039 Isrl.

The most promising introductions in the 1975 planting are: - P.I. 184936 Neth., 234938 Switz., 245128 N. Hamp., 251189 Yugo., 255185 Pol., and 256733 Iran.

4. Trefoil (Lotus corniculatus)

During the interval mid-June to July 15, notes were taken on uniformity, habit, vigor, plant size, number of stems per plant, size of stems - fine, medium, or coarse, leafiness, size of leaves, color of leaves, time of bloom, flower color, date of maturity, pod set, recovery after cutting, winter hardiness, and spring recovery.

The following introductions in the 1976 planting are considered promising and worthy of further evaluation: - P.I. 214110 Sp., 228233 Italy, 234806 Switz., 235076 Switz., 235101 Swe., 244036 Braz., 304280 Urug., 315453 USSR, and G23812 N.Y.

Promising Forage Grass Introductions - 1976

1. Tall Oatgrass (Arrhenatherum elatius)

The following introductions of tall oatgrass appear promising: - P.I. 251572 Yugo., 253293 Yugo., 302849 Sp., 318942 Sp., and 406308 USSR.

2. Smooth Bromegrass (Bromus inermis)

All of the promising smooth bromes still have Geneva numbers and have not yet been assigned P.I. numbers. They are: - G-23837 USSR and G-24099 Can.

3. Tall Fescue (Festuca arundinacea)

The following introductions are worthy of further trial and further evaluation: - P.I. 204447 Tur., 206270 Tur., 234047 Sp., 234717-18 Fr., 283282 Mor. and 316245 Mor.

4. Timothy (Phleum pratense)

The following introductions of timothy appear promising and worthy of further trial: - P.I. 406317-20 USSR, 406321 USSR, 406322-23 USSR, G-23597 Fr., G-24097 Can., and G-24098 Can.

Forage Legume Introductions1. Trefoil (Lotus corniculatus)

Performance of some USDA introductions under dryland conditions in North Island, New Zealand. Reported by M.B. Forde, Dept. of Scientific & Industrial Research, Grasslands Division, Private Bag, Palmerston, North.

P.I. 322556 Brazil. 1st. Good growth over 3 years, especially in first year. 50% survival. Intermediate habit.

P.I. 329242 Uruguay. 2nd. Excellent over 3 years. 80% survival. Erect.

P.I. 244036 Brazil. 6th. Satisfactory over 3 years. Not rapid in recovery after grazing. 64% survival. Erect.

P.I. 316267 Australia. 7th. Satisfactory. Poor recovery after grazing. 67% survival. Intermediate.

P.I. 262531 Israel. 9th. Moderate. Prone to drought. Rapid recovery after grazing. 67% survival. Intermediate.

P.I. 358997 Brazil. 10th. Satisfactory. Slow recovery after grazing. 50% survival. Intermediate.

P.I. 255303 France. 11th. Improved over 3 years. Rapid recovery after grazing. 80% survival. Intermediate.

P.I. 331177 Argentina. 12th. Moderate. Slow recovery after grazing. 50% survival. Intermediate.

P.I. 285280 USSR. 13th. Improved over 3 years. Rapid recovery after grazing but poor winter performance. 83% survival. Intermediate.

P.I. 300014 South Africa. 14th. Improved over 3 years. Prone to drought. Good recovery after grazing. 86% survival. Intermediate.

P.I. 322555 Brazil. 15th. Moderate. Drought prone. 62% survival. Intermediate.

P.I. 226798 Netherlands. 16th. Improved over 3 years. 72% survival. Erect.

P.I. 194228 Yugoslavia. 17th. Improved over 2 years, declined thereafter. Poor winter performance. 73% survival. Intermediate.

P.I. 260013 Brazil. 18th. Poor in 2nd. year, otherwise good. 65% survival. Erect.

P.I. 285284 USSR. 20th. Improved over 3 years. Poor winter growth. 80% survival. Intermediate.

Forage Grass Introductions

Following evaluated by R. W. Robertson, Research Station, Ontario, Canada.

1. Orchardgrass (Dactylis glomerata)

P.I. 325302 USSR - Leafy, tall, appeared quite hardy over 2 winters, with forage production higher than 'Kay'.

2. Timothy (Phleum pratense)

P.I. 342557 Netherlands - Late maturing, vigorous, gave considerably higher yields than 'Bounty'.

P.I. 372632 England - Leafy, tall, good fall growth and higher forage yields than 'Bounty'.

P.I. 311079 Rumania - Vigorous, late, many basal leaves, outyielded 'Bounty' in forage production.

P.I. 311082 Rumania - A timothy of medium height, higher in green forage production than the control, Champ.

P.I. 345666 USSR - A vigorous strain of timothy that outyielded Champ in forage production.

P.I. 305272 Swed. - A strain of medium height that gave higher yields than the control.

P.I. 311081 Rum. - A strain of medium height, lower than Champ in forage production.

P.I. 311080 Rum. - A tall strain that compared favourably with the control in forage production.

P.I. 345667 USSR - A strain of medium height that compared favourably with Champ in forage production.

P.I. 345665 USSR - A strain of medium height; slightly lower than the control in forage production.

P.I. 298093 Hung. - A tall timothy with lower forage yields than Champ.

P.I. 285540 USA - A tall vigorous line lower in forage production than Champ.

P.I. 285539 USA - A variable strain that had slightly higher forage yields than the control.

- P.I. 298094 Hung. - A tall vigorous strain that gave higher forage yields than the control.
- P.I. 311078 Rum. - A late low growing timothy with slightly higher forage production than the control.
- P.I. 305504 Pol. - A tall strain with slightly higher forage production than the control.
- P.I. 303130 USA - A tall strain that gave a good aftermath and higher forage yields than Champ.
- P.I. 372626 Can. - A strain of medium height with higher forage yield than the control.
- P.I. 345668 USSR - A tall strain with much the same forage yields as the control.
- P.I. 372628 Wales - A fine leaved low growing pasture type, produced few heads and lower forage yields than Champ.
- P.I. 345663 USSR - A tall vigorous strain higher in forage production than the control.
- P.I. 325461 USSR - Forage yields were much the same as the control.
- P.I. 325460 USSR - A tall, late maturing strain with forage yields that compared closely to Champ.
- P.I. 321682 Fr. - A late maturing strain that gave lower forage yields than the control.
- P.I. 383363 Wales - A low growing timothy, lower in forage production than the control.
- P.I. 381926 Fr. - A strain of medium height but lower than Champ in forage yields.
- P.I. 320559 Fin. - A strain of medium height but lower than the control in forage production.
- P.I. 315490 USSR - A line of medium height that produced less forage than the control.
- P.I. 315489 USSR - A tall late maturing strain that gave higher forage yields than the control.
- P.I. 311083 Rum. - A tall strain that gave lower forage production than Champ.
- P.I. 383364 Wales - A timothy of medium height but lower than the control in forage yields.

P.I. 274643 Pol. - A tall vigorous strain that gave lower forage production than the control.

P.I. 270543 Scot. - A tall growing type with lower forage yields than the control.

P.I. 284247 Austral. - A very tall strain with lower forage production than the control.

P.I. 284246 Austral. - A tall strain but lower than Champ in forage yields.

P.I. 284245 Pol. - A timothy of medium height with much the same forage production as the control.

P.I. 284244 Czech. - A tall strain with lower forage production than Champ.

Title: Breeding for Improved Forage Quality

Leaders: R. W. Cleveland, R. L. Cowan and J. S. Shenk, Pennsylvania

The characterization of genetic variability for plant constituents affecting forage quality in varieties and breeding source materials was initiated. In orchardgrass, additive and nonadditive genetic variances for first harvest in vitro dry matter disappearance (IVDMD) and crude protein were significant before adjustments were made for plant maturity differences, but only additive genetic variance was important after adjustment for maturity. Additive variance was most important for second harvest IVDMD and crude protein.

Alfalfa lines developed from plants selected for high forage quality were significantly higher in IVDMD and crude protein than check varieties when compared over years and harvests.

Significant variation for morphological traits, IVDMD and crude protein was found among plants within the crownvetch varieties, Penngift and Chemung. Morphological traits were not correlated with IVDMD.

An anti-quality constituent, β -nitropropionic acid "BNPA," was isolated and identified from crownvetch. The meadow vole "Microtus pennsylvanicus" bioassay was used in the detection of this compound.

Infrared spectroscopy analysis appears to be an accurate, rapid technique for screening large plant populations for variables associated with forage quality. Using samples of temperate legume and grass species, correlations between infrared analysis and laboratory analysis were 0.99 for crude protein, 0.98 for neutral detergent fiber, 0.96 for acid detergent fiber, 0.96 for lignin, and 0.95 for IVDMD.

Title: Breeding of Improved Varieties of Forage Species Adapted to the Northeast

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

Crownvetch. In a field study, clones were found to be consistent in their rankings for "in vitro" dry matter disappearance (IVDMD) when grown for two years in five states. Thus, real clonal differences in IVDMD appear to exist.

Orchardgrass. Different ways of synthesizing varieties for the four parental clones of Pennlate and Pennmead orchardgrass were studied. Conventional synthetics were compared in forage yield and quality with restricted polycrosses, single-cross synthetics made by crossing S(1) x S(1) and S(1) F(1) x S(1) F(1), and double-cross synthetics made from syn 1, S(1) x S(1), and S(1) F(1) x S(1) F(1) single crosses. Data were obtained from three years of field experiments and the following conclusions were made: 1. yields were ordered from high to low among restricted polycrosses, S(1) x S(1), and S(1) F(1) x S(1) F(1), respectively; 2. inbreeding did not affect the expression of GCA among clones of either of the two types of single-cross synthetics; 3. the yield rank order was reversed for double crosses derived from syn 1 single crosses compared with double crosses made from single crosses having inbred parents; 4. specific double-cross synthetics yielded similarly when derived from syn 1 single crosses or from S(1) F(1) x S(1) F(1) single crosses; 5. synthesis methods had a smaller influence on forage quality than on yield.

These results indicate that a considerable range of synthesis methodology may be used with similar results in breeding for yield and quality.

Title: Breeding and Cytogenetics of Alfalfa and Red Clover

Leaders: R. W. Cleveland and F. L. Lukezic, Pennsylvania

Alfalfa Breeding. Phenotypic recurrent selection programs for creeping-rooted alfalfa and persistence of normal-rooted alfalfas were continued. Plant selection, seed production, and evaluation of progenies were the principal activities. Lines that had high percentages of creeping-rooted plants were isolated.

Red Clover Breeding. Phenotypic recurrent selection for northern anthracnose and mildew resistances and persistence were continued. A composite-cross population derived from foreign and domestic strains was seed propagated. Work was pursued in plant selection, seed production and progeny evaluation.

Field trials of red clover and alfalfa varieties were evaluated. Alfalfa trials in southeastern Pennsylvania showed superior performance for varieties that are highly resistant to anthracnose, Saranac-AR and Arc. Anthracnose disease is a major factor in the performance of alfalfa in southern areas of the state.

Red clover trial results also showed probable effects of disease on forage yield. Kenstar, the best yielding variety in southern Pennsylvania tests, has resistance to southern anthracnose, a disease prevalent in that region. Whereas, varieties with northern anthracnose resistance e.g. Arlington" prevail in tests of central Pennsylvania. It is uncertain whether adequate resistance to both diseases is present in a single variety. Kenstar red clover and an experimental variety had outstanding persistence in a test planting in SE Pennsylvania. Lack of persistence is a limiting factor for the use of red clovers.

Title: Breeding of Perennial Forage Grasses

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

The orchardgrass recurrent selection program was continued with 4 populations A, B, C, D. The objective is to develop varieties with the potential to produce greater annual products/acre than current varieties. Our studies have revealed that progress in achieving this goal can best be made by visual evaluation of newly introduced germplasm as spaced plants followed by the testing of polycross progeny in small solid-seeded plots.

The characterization of genetic variability for plant constituents affecting forage quality in varieties and breeding source materials was initiated. In orchardgrass, additive and nonadditive genetic variances for first harvest in vitro dry matter disappearance (IVDMD) and crude protein were significant before adjustments were made for plant maturity differences, but only additive genetic variance was important after adjustment for maturity. Additive variance was most important for second harvest IVDMD and crude protein.

This genetic study indicated that family selection would be a good breeding procedure to carry out the recurrent "cycles" process over generations. Forage quality data are obtained by the infrared spectro-computer system. This information is used by a computer animal model which integrates total seasonal yield, protein, digestibility, and fiber for each entry in the field experiment into a single selection index value. This index, net dollars of milk/ha, is used to identify superior germplasm to be used in future cycles of selection.

Each population A, B, C, D has 100-200 parental clones classified as either medium or late maturity. Population A has undergone one cycle of selection and progeny have been selected and placed in the seed production nursery to produce seed for cycle 2. The first year evaluation of selected clones from population B was completed this year with final evaluation to follow next year. Seed has been obtained from clones selected from population C and D. Population C will be planted in mini-plots next spring to be field tested the following year.

Title: Breeding Crownvetch for Forage and Slope Stabilization Usage

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

Beta nitropropionic acid (BNPA), an anti-quality forage constituent, was evaluated in crownvetch forage for two years. Beginning in the spring, levels of this compound in the forage increased up to full bloom and declined thereafter. Flowers contained more BNPA than leaves and leaves more than stems. There were no important differences between varieties for levels of BNPA, but the percentage BNPA in first harvest crownvetch forage exceeded that in second harvest.

Title: Breeding and Genetics of Bromus inermis

Leaders: G. M. Dunn and H. Z. Lea, New Hampshire

Relatively few significant differences were obtained in yield among brome grass synthetics and varieties in two trials completed in 1976.

F₂, F₃ and backcross seeds were produced for the cross rolled-leaf mutant x self-fertile normal. Self-fertility in the mutant was very low. Reciprocal crosses between full sibs showed different segregation patterns for this trait.

Additional inheritance studies were initiated, as follows:

1) new virescent mutant x normal green and 2) yellow mutant x normal green. All F₁s of both crosses were green.

Five albino seedlings were produced in the M₁ generation by EMS treatment of polyhaploid (4N) brome grass, and a rolled leaf mutant was discovered at this ploidy level.

Title: Feasibility of Perennial Ryegrass and Hybrid Derivatives as Northern Forage Crops

Leaders: G. M. Wood, W. M. Sullivan and J. G. Welch, Vermont

A laboratory technique for screening juvenile grasses for cold tolerance was modified to utilize polyurethane insulation, instead of soil (see 1975 Report, page 40), as a means of creating a single freezing front similar to that in the field. More uniform results were obtained with this method. Significant varietal differences were found when a number of perennial ryegrasses and other forage grasses were thus screened for cold hardiness.

Field plots were established in September 1975 to provide yield, winter survival, and animal preference data. First year data showed significant differences for yield and survival. Although substantial differences were found in observed grazing intensities per plot, varietal differences were not significant.

<u>Grass</u>	<u>% Winter Survival</u>	<u>Yield T/HA</u>	<u>Grazing Preference*</u>
Tetrelite perennial ryegrass	25	6.42	82
Kentucky 31 tall fescue	50	3.36	71
Kenhy tall fescue	53	3.75	84
Massa perennial ryegrass	56	6.12	91
Pennmead orchardgrass	58	3.36	94
Kentucky bluegrass	61	3.55	100
Citation perennial ryegrass	69	4.97	73
Birdie perennial ryegrass	75	6.52	82
NK-200 perennial ryegrass	75	4.05	53
Game perennial ryegrass	75	6.12	61
Derby perennial ryegrass	81	5.13	77
Omega perennial ryegrass	81	5.43	73
K8-142 perennial ryegrass	81	7.11	82
Diplomat perennial ryegrass	83	4.97	78
Norlea perennial ryegrass	83	5.13	72
Eton perennial ryegrass	86	5.13	83

*Percent of Kentucky bluegrass

Title: Breeding for Pest Resistance, Yield and Quality in Alfalfa

Leader: R. R. Hill, Jr., U.S. Pasture Research Laboratory

A number of alfalfa cultivars included in NE-74 regional alfalfa variety trials were evaluated for reaction to Phoma, Stemphylium, Pseudopeziza, Leptosphaerulina, and anthracnose pathogens. All varieties were susceptible to Phoma, Stemphylium, and Leptosphaerulina, but significant differences in disease scores were observed for reaction to Pseudopeziza and anthracnose. Cultivars with known Flemish germplasm were generally more resistant to Pseudopeziza, and only varieties bred specifically for resistance scored well for reaction to anthracnose.

Theoretical investigations indicated that digenic parameters of auto-tetraploid populations play a role in response to selection on the basis of topcross progeny performance, and that trigenic parameters appear if the tester population is not in panmictic equilibrium. Nonadditive parameters never appear in similar equations for diploid populations. Response for full sib family selection based on topcross progeny composite performance was not different from that for half-sib family selection. Response for full-sib family selection is twice that for half-sib family selection for within population selection methods. Plants have been established for seed production in initial phases of a selection program to test accuracy of theoretical results.

Syn-3 seeds of experimental synthetics with 1, 2, 4, 8, and 16 parental clones (see page 12 of the 1975 Annual Report) were produced in the greenhouse during the spring of 1976. The synthetics will be established in field tests at two locations in the spring of 1977.

Title: Breeding Alfalfa for Tolerance to Aluminum Toxicity in Acid Soils

Leaders: J. H. Elgin, Jr., J. E. McMurtrey III, and C. D. Foy, USDA, Beltsville, Maryland

Using nutrient culture techniques, we are developing an Al-tolerant alfalfa strain for use on the acid subsoils of the Eastern U.S. A fourth-cycle screening was completed for tolerance to toxic levels of Al at pH 4.5. Evaluation of cycle 3 seedlings revealed 50% greater growth than the parent population when grown in Al-toxic conditions. Plans are being made to establish field plots in Al-toxic soils in Virginia with cycle 4 seed.

Title: Forage Grass Breeding, Genetics and Cytology

Leader: J. B. Powell, USDA, Beltsville, Maryland

Experiments have been continued to define and screen for genetic expression of the leaf penetration phenomena by rumen microbes. A new approach using chemicals to attack the surface waxes and cuticle of plants shows promise. The abaxial side of the leaf blade is much more easily penetrated by microbes than the adaxial side. Therefore, screening techniques have concentrated on the abaxial surface. Second-year field results in which 1140 plots were harvested showed soil-fumigated areas yielding much more forage than unfumigated areas. The interaction of varieties with soil fumigation is of primary interest in this experiment; however, relationships are not clear-cut. The tall fescue grazing study revealed marked varietal differences in animal response. One of the four varieties in the test known to contain low levels of alkaloid perloine caused poor gains, sensitivity to heat, behavioral difference, and generally poor performance. Tatum soil, low in pH, was used to screen mutant bermudagrass selections and checks. Good evidence was found that much progress can be made for development of less sensitive plants when grown on low pH soils. The cooperative project with the Instrumentation Lab gave some indication of difference in two tall fescue lines for infrared reflectance spectroscopy. Plant introductions from four countries where collections were made in 1975 have been increased. Winter survival has been good and material is now available for increasing seed of vegetatively-introduced clones.

Title: Breeding Alfalfa for Disease and Insect Resistance

Leaders: J. H. Elgin, Jr., J. E. McMurtrey III, S. A. Ostazeski, and R. H. Ratcliffe, USDA, Beltsville, Maryland

Attempts at interspecific hybridization of Medicago scutellata and M. rugosa (both found to be resistant to alfalfa weevil larval feeding due to gland-tipped hairs on the stems) with M. sativa have reached an impasse. The few seeds obtained from approximately 1,100 crosses all appeared to have resulted from self-pollination. Additional attempts at interspecific hybridization by excising aborting, suspect-hybrid embryos from pods and transferring to tissue culture media have been only moderately successful. Callus tissues were obtained which grew vigorously; however, although some roots developed, only green mounds of cells have been obtained after several attempts to get plantlet differentiation.

Over 900 plant introduction lines were evaluated for field response to potato leafhopper infestation. Although there was a wide range in sensitivity to the leafhopper feeding, two Peruvian entries regrew quickly after cutting, were markedly greener than surrounding entries, and appeared to have reduced leafhopper infestation. Further studies with these entries are underway.

Cycle 2 screening for resistance to Fusarium wilt and Mycoleptodiscus root and crown rot was completed. Preliminary evaluation of first-cycle progress revealed significant improvement for resistance to Fusarium wilt but little improvement for resistance to Mycoleptodiscus.

A new breeding procedure was designed to capitalize on complementation of dominant genes for pest resistance contributed by the parent strains during the seed increase phase. Evaluations of the levels of resistance to nine pests in six resultant populations were completed at St. Paul, Minnesota, and University Park, Pennsylvania. Evaluations are still underway at Reno, Nevada, Prosser, Washington, Manhattan, Kansas, and Beltsville, Maryland.

Title: Response of Kentucky Bluegrass, Tall Fescue, and Fineleaf Fescue Cultivars to Lime on an Acid Soil High in Exchangeable Aluminum

Leader: J. J. Murray, USDA, Beltsville, Maryland

The immediate objective was to determine the range of tolerance among cultivars to acid aluminum-toxic soil. The long-range objective is to develop through breeding germplasm better adapted to acid soil-stress conditions.

Thirty-six Kentucky bluegrass, 15 fineleaf fescue, and 6 tall fescue cultivars were grown in an acid, Al-toxic Tatum subsoil limed to two pH levels. Tolerance was determined by comparing dry weight of tops and roots at the two pH levels. Cultivars within each species differed significantly ($P < .05$) in tolerance to acid soil. Differences were greatest among Kentucky bluegrass cultivars, followed by tall fescue, and fineleaf fescue. Relative top yields (pH 4.6/pH 5.7%) of bluegrass cultivars, ranged from 4% for Windsor to 62% for Fylking. Relative root yields ranged from 6% for Kenblue to 102% for Victa.

Eleven of the 15 fineleaf fescue cultivars tested made good growth in soil at pH 4.3. Tall fescue cultivars were much more sensitive to acid soil than were the fineleaf fescues. Kentucky 31 was the most tolerant. However, clipping yield on the low lime (pH 4.3) treatment was only 35.4% of that on the high lime (pH 5.7) treatment. Fawn and Goar were the most sensitive varieties, having relative yields of 1.8 and 7.9%, respectively. Although the tall fescue varieties in general were sensitive, a few plants within cultivars showed a high level of tolerance. This suggests the practicability of selecting and developing cultivars for increased tolerance in this species.

A recurrent selection program has been initiated to increase tolerance in tall fescue. Three-hundred clones from Kentucky 31 and 300 from Alta showing tolerance have been selected for intercrossing.

Title: Scientific Names for Crop Plants

Leader: E. E. Terrell, USDA, Beltsville, Maryland

Two publications of interest for forage research were published or are in press. One publication was a study of the correct names for pearl millet and yellow foxtail. It was concluded that these names are Pennisetum americanum (L.) Leeke and Setaria glauca (L.) Beauv. These names are in agreement with the rules established in the International Code of Botanical Nomenclature, 1972 edition. At least five different scientific names have been used in the past for pearl millet, and it is hoped that this controversy can be settled on an international basis.

An Agriculture Handbook scheduled for publication in May, 1977, provides scientific names for 3,000 taxa, mostly species, plus 700 synonyms. Part one will list scientific names alphabetically, part two common names alphabetically. The purpose of this publication is to provide up-to-date scientific names for many major and minor crops grown anywhere in the world for food, fiber, or medicine. Also included are many timber and ornamental plants as well as many common weeds. Many scientific names have been in a state of flux, and this publication should provide an authoritative, up-to-date reference source for economic plant names.

Title: Breeding Trefoil for Resistance to Stemphylium loti

Leaders: H. M. Schaaf and R. L. Millar, New York (Cornell)

All but two of about 300 trefoil selections tested against S. loti were highly susceptible. The two exceptions always showed marked hypersensitivity to repeated inoculation. Unfortunately, both plants have so far been not only male- and female-sterile, but also self-sterile. Reasons for the sterility are being sought in cytological and histological examinations. Thirty trefoil accessions from the Geneva Plant Introduction Station are currently being screened and several plants with apparent resistance to infection by S. loti have been isolated.

Title: Breeding Birdsfoot Trefoil for Improved Persistence

Leader: H. M. Schaaf, New York (Cornell)

Tests conducted at several "problem sites" in the Champl ain Valley indicated that root rots were the direct cause of trefoil stand losses. Comparison of data from such sites with those from a "non-problem site" suggested that genotypes inherently low in vegetative vigor tended to be lost rapidly at the problem sites.

Preliminary results from a study in which methyl bromide fumigation and phosphorus fertilization variables were imposed in a problem site indicate that survival of one-year-old trefoil plants is conditioned by an important phosphorus x fumigation interaction. The same was true of vegetative vigor of the survivors, except that phosphorus had a favorable effect in the absence of fumigation. The large difference in survival between fumigation alone and phosphorus + fumigation suggests a problem in winter mortality that is separate from disease. Phosphorus + fumigation not only greatly improved survival but also gave a nearly normal distribution of the vigor scores of individual plants. Vigor scores in the check (untreated) plots showed distinct, positive skewness.

Title: Breeding and Cytogenetic Investigations and Improvement of Cool Season Perennial Forage Species

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

Field selection for tolerance to the alfalfa snout beetle has been discontinued. A nursery established in an infested area in Wayne County, New York, failed to produce sufficient populations of the insect to evaluate feeding damage. Since it is not the type of an insect that should be moved outside infested areas, other screening procedures are not feasible. Alfalfa types with fibrous branching root systems were being looked at as a possible source of snout beetle tolerance. Casual observation of alfalfa in the infested areas indicates progressive dairymen who are using recommended cultural practices are getting good performance from alfalfa despite the presence of the snout beetle. Insect populations apparently fluctuate widely in different seasons.

Surviving alfalfa plants from Phytophthora disease tests in Minnesota and New York have been used as parents for synthetic populations. These will be evaluated for forage production. Experience to date with Phytophthora resistant or tolerant varieties in New York has shown relatively little practical benefit in forage production. Under very wet conditions where the disease is present, all strains have tended to go out; and under growing conditions where drainage is reasonably favorable, all strains tend to survive. A survival difference was observed at one location but the production level of alfalfa under the drainage conditions where this occurred was not economic for any alfalfa. There is some indication that higher levels of resistance are possible. Current thinking is to incorporate very high resistance in varieties most tolerant of marginal drainage.

A selection nursery for the alfalfa blotch leafminer is maintained in the Hudson Valley of New York where the insect first entered the state. It is now present in very large numbers in Central New York so all breeding nurseries can be observed for its effects. There is no indication yet on possible genetic variance for tolerance or resistance to this insect. There is also considerable uncertainty as to the extent of its damage to alfalfa. Very high populations currently exist but feeding injury is in no way comparable to the effects of the alfalfa weevil or potato leafhopper.

New source materials in alfalfa derived from (2X x 4X) crosses are being developed. Emphasis will be placed on intensive management survival, spreading crowns, quality parameters and higher levels of wilt and anthracnose resistance as means of further improvement of forage potential in this crop.

Selection in timothy is continuing for high seed production potential and stability for quality expression. Economic levels of seed production are a continuing problem with this species. It is a widely adapted humid climate species that is only marginally adapted to the semi-arid regions where most grass seed is grown. Combination of seedling vigor and regrowth potential of early maturity types with the quality characteristics of delayed anthesis is a breeding objective.

SECTION II

ENTOMOLOGY RESEARCH

Title: Systemic Insecticides with Spring Seeded Alfalfa for Potato Leafhopper Control, a New Management Concept

Leaders: R. A. Byers, J. W. Neal, Jr., and J. H. Elgin, Jr., U.S. Pasture Research Laboratory and Beltsville Agricultural Research Center

Systemic insecticides (2.24 kg AI/ha of broadcast granular carbofuran, of a phorate- or ethoprop-disulfoton combination, or of flowable carbofuran in a tank mixture with preemergence herbicide) applied at planting of spring-seeded alfalfa were more effective in controlling potato leafhopper, Empoasca fabae (Harris), in Maryland where the population peaked in late June than in Pennsylvania where it peaked in early July. However, treatments reduced populations of potato leafhoppers, resulted in taller plants, prevented stand loss of 2 of 3 tests, prevented any significant loss of yield when conventional harvesting methods were used, and resulted in plants with significantly larger root diameter. Treated alfalfa appeared greener than untreated alfalfa, but chemical analyses did not show that it was higher in quality.

Title: Effect of the Alfalfa Blotch Leafminer Upon the Quality of Alfalfa

Leaders: R. A. Byers and Karl Valley, U.S. Pasture Research Laboratory and Pa. Dept. of Agriculture, Harrisburg

The alfalfa blotch leafminer, Agromyza frontella (Rondani) had at least 4 complete generations a year in Pennsylvania. The highest average percentage of leaflets with large blotch mines was attained by generation 2 in July 1974 in Reading, Pa., and also in July 1975 at University Park, Pa. The insecticides carbofuran and dimethoate caused high mortality of first instar larvae in linear mines. However, mortality of older larvae occurred from other agents in untreated areas in July and August both years. Many linear mines and beginning blotches were empty, evidence of insect predators. Large blotch mines contained parasitized larvae. The combined action of predators and parasites appeared to reduce the leafminer population to a low level in August both years.

Samples of field-grown alfalfa showed no differences in protein or digestibility between treated and untreated areas. Furthermore, stress meter tests showed that blotched leaves did not shatter any differently than normal leaves. However, the forage quality analysis used 0.5 g samples which biased the results because it took more leaflets (greater volume) infested with the leafminer than undamaged leaflets to acquire a 0.5 g aliquot. Whenever the analysis was repeated on 1000 leaflet pairs, one member of the pair having one blotch mine, the opposing leaflet being undamaged, then in vitro digestibility was reduced 7-9%, protein reduced 6-9.4% and dry wt. 5.4-6%, depending upon the time of year the sample was taken. Using these data as an index, a conservative estimate of loss in quality for a 10-20% infestation was 0.6-1.2% loss in protein, and 0.7-1.8% loss in digestible dry matter. Losses caused by more than one blotch mine per leaflet were not considered in the estimate. If the incidence of multiple blotches becomes greater than what we observed in this study, then loss in alfalfa quality may become economically important. The insect probably has not attained its maximum population density and is still increasing in most of the east. Populations at University Park are much higher this year and we expect significant losses in quality.

Title: Sweep-Net Survey of Insects on Eight Forage Grasses

Leaders: R. A. Byers and G. A. Jung, U.S. Pasture Research Laboratory

The most abundant insects collected during a sweep-net survey in 1971-72-73 to determine the important insect species attacking perennial forage grasses were: leafhoppers (13 species); the frit fly, Oscinella frit (L.); 10 species of Orthoptera; 2 species of flea beetles, Chaetocnema pulicaria Melshimer, and Systema frontalis (F.); a plant bug, Trigonotylus ruficornis of authors not Geoffroy; and the meadow spittlebug, Philaenus spumarius (L.). More leafhoppers, frit flies, and Orthoptera were collected from grasses fertilized with nitrogen (60, 120, or 240 kg N/ha) than from unfertilized grasses; more meadow spittlebugs were collected from unfertilized grasses.

Leafhoppers and flea beetles were most abundant on Kentucky bluegrass, Poa pratensis L.; frit flies and T. ruficornis on reed canarygrass, Phalaris arundinacea L.; and meadow spittlebugs on orchardgrass, Dactylis glomerata L. Orthoptera were evenly distributed among the grasses. Thrips (5 species) were most abundant on timothy, Phleum pratense L., in 1972.

Fewer leafhoppers were collected after insecticides were applied in 1972 and 1973. Application of carbofuran (2,3-dihydro-2,2-dimethyl-7-benzofuranyl methycarbamate) significantly increased the mean yield of dry matter in August 1973.

Title: Carbofuran Degradation Studies

Leader: G. B. MacCollom, Vermont

Spray plots on birdsfoot trefoil were established for carbofuran degradation studies at 1 and 0.5 lbs. active/acre, at 0 and 28 days following application.

Efficacy data on carbofuran at 1 and 0.5 lbs. active, dimethoate at 0.5 lb. active, and carzol at 0.5 lb. active for control of the tarnished plant bug, alfalfa plant bug, on birdsfoot trefoil grown for seed were collected by weekly sweeps and seed yields. Extremely wet weather during June and July of 1976 resulted in delayed seed harvest which failed to show difference between treatments.

Studies were continued on the alfalfa blotch leafminer to ascertain effect on yield and quality of alfalfa hay from first and second cuts. No significant difference in yield could be shown between insecticidal treatments and check. Carbofuran gave excellent control of the leafminer with visually apparent differences, but such differences were not reflected in yield or crude protein content. It is felt that this insect's primary impact may be leaf shattering during field curing and baling, resulting in protein loss and lowered palatability due to increase in stems. Investigations into this aspect are continuing.

Table 1. Yield, Protein from Carbofuran and Check Treatments.

Treatment	A.I. rate/acre	Yield in lbs dry wt per acre		% Protein	
		1st cut	2nd cut	1st	2nd
Carbofuran	0.5 lb	4135	2848	17.11	21.75
Check	--	4036	2827	17.38	20.58

Table 2. Protein Content from Hand-sampled Blotched and Unblotched Leaves, Stems and Total Plants.

	% Crude Protein		Avg. wt. of leaflet	
	1st cut	2nd cut	1st cut	2nd cut
Unblotched leaflets	32.67	34.82	8.8 mg	4.0 mg
Blotched leaflets	31.32	27.29	7.9 mg	3.7 mg

Stems from unblotched plants	--	13.84	--	--
Stems from blotched plants	--	11.28	--	--

Title: Control and Bionomical Studies of Livestock and Animal Food Crop Insects in West Virginia

Leaders: Linda Butler and Joseph E. Weaver, West Virginia

The alfalfa weevil parasite, Bathyplectes anurus, is established at release sites in 12 of 16 counties: At the earliest (1970) release site, populations have continued to increase and levels of parasitism of more than 15% were recorded in 1976. This parasite has dispersed from the 1970 release site and is established at one farm seven miles distant.

Excellent control of alfalfa weevil larvae was obtained with Chemagro SRA-12869 6E at 1.0 lbs. a i/A for 3 weeks; SRA-12869 6E at 0.5 lbs. a i/A and NTN-9306 6E at 0.75 lbs. a i/A gave excellent control at one week post-treatment, but only good control at three weeks. The SRA-12869 compound shows some promise for leafhopper control giving good to fair control at one and two weeks, respectively.

Insect growth regulators Thompson-Hayward 6041, 6052 and Dimilin; HLR Sciences Ro 10-3108/018 and Stauffer R-20458 were applied at two rates each for alfalfa weevil control. Significant reduction in insect numbers was obtained only with Dimilin and TH-6041.

Title: Yellow Sugarcane Aphid Resistance in Digitaria Species

Leaders: R. H. Ratcliffe and A. J. Oakes, USDA, Beltsville, Maryland

Plants of Digitaria friesii, P.I. 364357, and pangolagrass, P.I. 111110, were exposed to yellow sugarcane aphid infestations for 1, 2, 3 and 4 weeks in greenhouse tests. Aphid populations were moderate to heavy on the susceptible pangolagrass after 3 weeks and very heavy after 4 weeks of infestation. Aphid populations on the highly resistant P.I. 364357 increased moderately for 1-2 weeks, but then began to decline and remained at a low level. The level of antibiosis in P.I. 364357 was effective in preventing significant damage by the aphid under these conditions. After 4 weeks of infestation there was only a 9% loss in dry matter yield and 3% loss in protein content in infested plots of P.I. 364357 as compared to uninfested plots. Under the same conditions, there was a 41% loss in dry matter yield and 17% loss in protein content in infested pangolagrass plots as compared to uninfested plots.

Title: Alfalfa Weevil and Potato Leafhopper Resistance in Annual
Medicago Species

Leaders: R. H. Ratcliffe and J. H. Elgin, Jr., USDA, Beltsville,
Maryland

Medicago scutellata and M. rugosa lines which were highly resistant to alfalfa weevil larvae in laboratory tests were evaluated for resistance in a field space planting during the summer of 1976. Fifty plants of a single line of M. scutellata, and M. rugosa and Saranac were transplanted in the field in May. All plants were infested with 5 alfalfa weevil females on June 3, and subsequently were exposed to a heavy natural potato leafhopper infestation. Female weevils laid as many eggs in stems of M. scutellata and M. rugosa as in Saranac, however, larval survival was very low and little feeding damage occurred on the annual species while Saranac was heavily damaged. Saranac plants were also severely stunted and discolored due to potato leafhopper feeding while the annual species showed no evidence of feeding. Large numbers of leafhopper adults and nymphs were collected from Saranac, but very few from M. scutellata or M. rugosa. Results indicated that the production of a sticky exudate by glandular tipped hairs on stems and petioles of M. scutellata and M. rugosa was sufficient under field conditions to effectively trap high numbers of immature insects of both species and significantly reduce feeding damage.

Title: Identification of Insects and Mites Important to Forage Crops

Leader: R. W. Hodges, USDA, Beltsville, Maryland

It is the function of the Systematic Entomology Laboratory to conduct and publish research on the systematics of insects and mites affecting forage plants and to provide authoritative identification of those insects. During the past 25 years a number of taxonomic papers have been published concerning the taxonomy of forage crop insects. The authoritative identifications of pests and beneficial insects and mites affecting forage crops are basic and essential to the conduct of many agricultural programs.

Title: The Alfalfa Weevil and Its Related Parasites in 10 Maryland Alfalfa Fields - 1976

Leader: R. F. W. Schroder, USDA, Beltsville, Maryland

Alfalfa weevil larval populations in 1976 were about the same as in 1975; however, damage was greater since the weevil was 2-3 weeks early and the alfalfa was only 8-12 inches tall. (Surveys showed that 90% of the farmers sprayed against the weevil in 1976.) Bathyplectes curculionis, a larval parasite of the alfalfa weevil, is most effective

Peak # Larvae/ft ²	Field #										\bar{x}
	1	2	3	4	5	6	7	8	9	10	
1975	120	150	79	414	115	59	239	233	188	335	188
1976	162	193	166	220	260	113	84	142	253	142	174

when the parasite is synchronized with the peak larval development. Surveys in 1976 showed a complete lack of synchronization coupled with an increase in alfalfa weevil populations. Tetrastrichus incertus, a midseason larval parasite, was recovered for the first time since 1970 at Beltsville. The effectiveness of Bathyplectes anurus is unknown since it has only been found at very low levels in central Maryland. The effectiveness of Microctonus parasites in controlling the weevil is unknown.

Title: Chemical and Biophysical Control of Insects

Leaders: D. K. Hayes and W. N. Sullivan, USDA, Beltsville, Maryland

Methodology has been implemented for determining 3-hydroxykynurenine (3-OHK) in insect tissue. Larvae reared in LD 10:14 contained more 3-OHK than those reared in LD 16:8. Early findings suggest that 3-OHK can be bound to proteins. Cyclic AMP-ase activity was higher in extracts of whole late 3rd and early 4th instar larvae of the European corn borer, Ostrinia nubilalis Hübner than in other instars. Adenyl cyclase activity was found in heads of 18-day old European corn borer larvae reared in LD 16:8. An automated system for continuously determining oxygen uptake in 10-30 mg of insect tissue has been installed; anomalies in oxygen utilization by insects exposed to UV-B have been demonstrated. Derivatization of phenylalanine and leucine has enhanced the uptake of these materials from solution over the free amino acids. Rabon, famphur and diflubenzuron have been encapsulated or encased in polymer matrices for slow release.

Title: Plant-Parasitic Nematodes on Grasses

Leaders: Julius Feldmesser and S. A. Ostazeski, USDA, Beltsville, Maryland

Studies being made of nematode population dynamics in perennial bluegrass turf, the "Plain," the 9.3 acre parade ground at the U.S. Military Academy, West Point, New York, under the stress of annual nematicide applications, indicate that reductions in nematode numbers after treatment are related to accelerated grass growth, reduced chlorosis, and highly improved general appearance. High nematode numbers are associated with irregularly-shaped chlorotic and/or stunted patches. The nematodes are mainly Tylenchorhynchus and Criconeomoides, occurring as mixtures. Other nematodes such as Helicotylenchus, Pratylenchus, and Hoplolaimus are also present but occur less frequently in samples.

The relationships between symptoms and nematode population levels are less clear in turf and pasture grasses in Maryland infected with these nematodes. Nematodes are reduced by chemical treatments but growth rates, measured as clipping weights, are short of significance and expression of symptoms characteristic of nematode infections is difficult to detect.

Population and chemical control studies are continuing to help elucidate the roles of plant-parasitic nematodes in grass production.

Title: Isolation and Characterization of Chromosomal and Plasmid DNA from Entomopathogenic Bacteria for Use in Transformation and Recombinant DNA Studies

Leader: Robert M. Faust, USDA, Beltsville, Maryland

High molecular weight chromosomal DNA of Bacillus thuringiensis and Bacillus popilliae for use in transformation and recombinant DNA studies in Bacillus popilliae has been isolated and purified. Super-coiled DNA plasmids have been also isolated from Bacillus thuringiensis and have an approximate molecular weight of $10-12 \times 10^6$ daltons. The technology being developed is aimed at resolution of the in vitro sporulation problem with Bacillus popilliae, a pathogen of Japanese beetle grubs and other white grubs, and will be used as a model system in attempts to broaden the spectrum of Bacillus thuringiensis for insect pests.

Title: Cation Requirements of Bacillus thuringiensis var. kurstaki

Leader: Robert M. Faust, USDA, Beltsville, Maryland

Definitive studies on the cation requirements for growth, sporulation and δ -endotoxin production of Bacillus thuringiensis, a commercial pathogen for Lepidopterous insects, revealed that 1.2×10^{-5} M Mg was essential for maximum growth. Optimum levels of cations for sporulation and toxin production were: Ca, 0.003 M; Mn, 0.00003 M; Fe, 0.003 M; higher concentrations were inhibitory. Zn, Cu, Co, Ba and Cd were stimulatory or inhibitory depending on concentration. Sn, Pb, Al and Ni were toxic at all levels. These findings emphasize that knowledge of quantitative and qualitative cation composition in commercially ill-defined fermentation media could be crucial to optimum production of the parasporal crystals containing the toxic agent.

Title: Inhibition of Adenosine Triphosphate Production by Bacillus thuringiensis var. kurstaki δ -endotoxin

Leader: Robert M. Faust, USDA, Beltsville, Maryland

Investigations on the molecular mode of action of Bacillus thuringiensis var. kurstaki δ -endotoxin revealed that its ability to uncouple ATP production from the electron transport system causes a drop in NADH level to 0. P/O ratios of the system remained at less than 25% of normal with an increase of oxygen uptake at certain levels of toxin. The fall in ATP levels inhibits formation of trehalose and uptake of glucose in susceptible Lepidopterous insect pests.

Title: Effect of Ozone on Expression of Pea Aphid Resistance in Alfalfa

Leaders: T. C. Elden and R. K. Howell, USDA, Beltsville, Maryland

Pea aphid resistance or susceptibility in selected alfalfa lines or cultivars was not significantly altered after exposure to high levels of ozone, although aphid survival was slightly higher on all ozone-treated plants. Tests were conducted in the laboratory with the pea aphid resistant entries MSACW3AN3 and Team, and susceptible entries MSBCW5AN3, Mesa-Sirsa, and Williamsburg.

Title: Systemic Insecticides with Spring-Seeded Alfalfa at Private Farms for First Crop Control of Potato Leafhopper, 1976

Leader: J. W. Neal, Jr., USDA, Beltsville, Maryland

Studies were conducted at 6 Maryland farms to determine the feasibility of soil-incorporated systemic insecticides for insect control as well as grower acceptance. Carbofuran (Furadan) G and F and disulfoton (Disyston) EC were applied at 2.24 kg AI/ha (2.0 lb AI/a) to areas 2 to 4 acres in size. The flowable and liquid formulation were applied with conventional farm equipment as a tank mix with the herbicide EPTC; the granular was applied with a Gandy Agricultural Spreader.

Insect populations were generally low at 3 locations due to the failure of normal spring storms to develop from the Southwest. Spring storms carry the adult potato leafhopper northeastward from the Gulf States. Insect surveys at first cutting showed significant reductions of potato leafhopper adults and nymphs when present in insecticide treated areas. The granular formulation of Furadan was more effective than the flowable. Disyston significantly suppressed potato leafhopper adults and nymphs but was not as effective as the flowable Furadan. Other species of leafhoppers were significantly suppressed below untreated population levels in 5 of 6 fields with each insecticide treatment.

Residue analysis of forage taken at harvest showed furadan metabolites to be within established tolerance limits. Economic conclusions other than insect control could not be made due to the influence of the weather. All growers expressed strong satisfaction with the test.

Title: Computer Modeling of Alfalfa Production

Leaders: Gary W. Fick, Beverly Wen-Yuh Liu, and George A. Maybee, New York (Cornell)

The first generation computer model of alfalfa production called ALSIM 1-LEVEL 1 was reasonably accurate in predicting alfalfa yields in the Northeast under two- and three-cut managements. When coupled with models of the population dynamics and feeding behavior of the alfalfa weevil, optimal management strategies to control the insect also appeared to be reasonable in light of field experience. The preliminary model, however, became increasingly inaccurate, overestimating forage yield and underestimating root reserves, as the number of simulated harvests was increased. The apparent cause of the errors was an inaccuracy in the rate and pattern of dry matter distribution in the initial stages of regrowth following a harvest.

To more closely investigate the problems of modeling regrowth, a series of simple computer programs (REGROW I to III) representing different regrowth mechanisms were compared. The mechanism including both regrowth buds and root reserves could more accurately simulate a variety of real system experiments than simpler models with only root reserves or regrowth buds included in the model structure. The ALSIM 1 model was modified (as LEVEL 2) to include the most versatile regrowth mechanism. A soil water, evapotranspiration section based on the Ritchie model was added and verified for New York State conditions. Work continues on improving the photosynthetic predictions of ALSIM 1.

Field studies to collect validation data for alfalfa production with alternative methods of alfalfa weevil control were continued in 1976. Periodic measurements were made of herbage yield, crude protein, digestibility, taproot reserves, and insect populations in cooperation with the Departments of Plant Breeding and Entomology. Studies were also conducted in controlled environments to develop equations to predict crude protein and digestibility from information about age and environment.

SECTION III

PLANT PATHOLOGY RESEARCH

Title: A Myrothecium Leafspot of Lotus corniculatus and Lotus spp.

Leader: S. W. Braverman, New York (Geneva)

The causal agent of a leafspot, identified as Myrothecium verrucaria, was prevalent on birdsfoot trefoil (Lotus corniculatus) in the Plant Introduction plots, N.Y. State Agricultural Experiment Station, Geneva. Foliar lesions were 2-5 mm in diameter, grayish tan, and occasionally had a brown margin.

The fungus was isolated from Empire, Mansfield, and Fargo and from L. gebelia var. hirsutissimus. In greenhouse inoculations, 67 introductions and nine cultivars of L. corniculatus, 33 Lotus spp. and four miscellaneous legumes were inoculated to determine the pathogenic effects of M. verrucaria on accessions L. corniculatus and to investigate the reaction of Lotus spp. and other legumes to the fungus.

L. corniculatus P.I. numbers 315450-454 and 325379, L. creticus P.I. 311429, L. aff. decumbens P.I. 311427, L. major P.I. 300016, and L. pusillus P.I. 238336 were rated as resistant. Fifteen accessions and six cultivars of L. corniculatus were slightly susceptible to the fungus, while the remaining Lotus corniculatus and other Lotus spp. were moderately to highly susceptible. Medicago sativa, Trifolium ambiguum, T. pratense, and T. repens were also susceptible under greenhouse conditions. This is the first report of M. verrucaria causing a leafspot of Lotus spp. under field conditions and pathogenic on several Lotus spp. and other miscellaneous legumes under artificial inoculations.

Title: Trefoil Root-rot Studies

Leader: A. R. Gotlieb, Vermont

Trefoil in seed fields suffering from root rot of unknown etiology were subjected to an intensive attempt to isolate a causal organism. Fusarium sp. was commonly isolated in non-selective media. Using selective media for Pythium and Phytophthora, isolation attempts from root lesions yielded more than 400 Pythiaceous fungus isolates. Approximately 100 cultures have been placed in axenic culture through transfer of single hyphal tips. Based upon cultural characteristics,

growth rate, and spore size, these cultures have been segregated into 5 major groups. Koch's postulates have been completed for fungi within all of the 5 major groups. Isolates within each group have the capacity to cause root necrosis under greenhouse conditions.

Disease conditions during the 1976 growing season were severe. More than 23 inches of rainfall was recorded leaving fields wet for long periods of time. Fungicide seed treatment trials were not found to be effective under the severe wet conditions experienced last year.

Title: Diseases of Warm-season Grasses

Leader: K. E. Zeiders, U.S. Pasture Research Laboratory

In August 1976, there were wide differences in amount of spot-blotch disease caused by a species of *Helminthosporium* among seven switchgrass genotypes in a field test in Huntingdon County, Pa. On a 1-9 scale, entry means ranged from 2.3 (slight) for Ky 729 to 6.4 (severe disease) for 'Carthage-75.' 'Blackwell' averaged 4.6; four other entries were lower than 4.6. Several isolates of the causal fungus have been obtained. Genotypes of little bluestem, big bluestem, and Indiangrass had very little leaf disease. In July 1976, *Ascochyta brachypodii* and a species of *Mycosphaerella* were associated with a leafspot and blotch disease on big bluestem cultivars growing at the Western Pennsylvania Forage-Beef Farm near Delmont, Pa. *A. brachypodii* was previously isolated in 1972 from big bluestem lines with severe leafspot and blotch at the Big Flats Plant Materials Center at Big Flats, N.Y.

Title: Purple Leafspot Resistance in Orchardgrass

Leaders: K. E. Zeiders, C. C. Berg, and R. T. Sherwood, U.S. Pasture Research Laboratory

Polycross seed for the third cycle of recurrent phenotypic selection for resistance to purple leafspot caused by *Stagonospora arenaria* was harvested in July 1976 from 350 selected clones in a replicated field planting. There were significant differences (0.01 level of probability) among clones in maturity and number of heads (June), and in reaction to naturally occurring purple leafspot, stem rust, and leaf rust (August). On a scale of 1 (no disease) to 9 (very severe), 85% of the clones had a low mean purple leafspot rating of 3.0 or lower for 4 plants. The third cycle of selection is being conducted in the greenhouse on polycross progeny of the best 156 clones.

Title: Reaction of Reed Canarygrass Genotypes to the Leafspot Pathogens Stagonospora foliicola and Helminthosporium catenarium

Leaders: K. E. Zeiders and R. T. Sherwood, U.S. Pasture Laboratory,

Studies were conducted to determine the range of reactions to tawny blotch (caused by Stagonospora foliicola (Bres.) Bubak) and Helminthosporium leafspot (caused by H. catenarium Drechs.) among diverse genotypes of reed canarygrass (Phalaris arundinacea L.), to assess the relationships among lesion size, lesion frequency, leaf size and tawny blotch severity ratings, and to assess the feasibility of selecting for resistance as a means of improving this highly productive forage species.

The 24 clones varied from resistant to highly susceptible to S. foliicola or H. catenarium in artificial inoculations. Differences among disease severity means for both pathogens were significant at $P < 0.01$. Resistance to S. foliicola was controlled independently from resistance to H. catenarium. One clone was resistant to both pathogens. There was a wider range of reaction among clones to S. foliicola than to H. catenarium.

Differences in lesions per leaf, lesions per cm^2 , and lesion size rating for S. foliicola were significant at $P < 0.01$. There was a significant negative correlation ($r = -0.60$) between leaf area and lesions per cm^2 . Lesions per leaf and lesion size were correlated ($P < 0.01$) with disease severity ratings ($r = 0.69$), thus supporting the validity of our disease severity evaluations. The results indicate that the prospects for developing lines with resistance to either or both pathogens are good.

Title: Foliar Disease: Effect on Protein and Carbohydrate in Leaves of Alfalfa and Orchardgrass

Leaders: A. Mainer and K. T. Leath, U.S. Pasture Laboratory

The effects of foliar disease on crude protein (CP), total nonstructural carbohydrates (TNC), and dry matter (DM) percentages were investigated with alfalfa and orchardgrass infected with Phoma medicaginis and Stagonospora arenaria, respectively. Similar results were obtained with both host-pathogen combinations: CP and TNC decreased and DM increased in diseased leaves as disease severity increased. Major changes in CP, TNC, and DM occurred in alfalfa leaves when disease severity was $> 80\%$. CP was significantly reduced in orchardgrass leaves by moderate, and TNC by severe disease levels, and DM increased at all levels of disease.

Crude protein was higher in healthy, new growth from diseased alfalfa plants than in that from healthy plants. A similar pattern was observed in orchardgrass. In bulk harvests of orchardgrass, which included all classes of disease severity, the TNC percentage was reduced by disease. Actual yields of dry matter and TNC were also reduced by disease in bulk harvested orchardgrass. We concluded that foliar disease of both alfalfa and orchardgrass reduced the TNC and CP of leaf tissue sufficiently to adversely affect the quality of the forage and that the loss of TNC was greater than was that of CP.

Title: Fusarium Root Rot of Forage Species: Pathogenicity and Host Range

Leaders: K. T. Leath and W. A. Kendall, U.S. Pasture Research Laboratory

The pathogenicity of Fusarium spp., isolated from diseased roots of forage plants, was compared on several forage species in nutrient solution culture. Fungi were grown on polyester cloth strips atop V-8 juice agar, and these strips were used to inoculate individual roots. The length of rot, frequency of infection, and inhibition of root growth were used to rate pathogenicity. The length of rot was positively correlated with inhibition of root elongation. Root tips were more susceptible to attack by Fusarium spp. than were root segments 2 cm above the root tip. Some fungi did not cause rot symptoms except at the root tip. Roots inoculated at the root tip often ceased elongation before penetration by the fungus occurred. White clover and birdsfoot trefoil were the most susceptible to root rot caused by Fusarium spp.; orchardgrass and crownvetch were the most resistant; and four other forage species were intermediate. Stress treatments, consisting of clipping, foliar disease, and darkness, reduced root growth but did not affect root rot development in red clover. The relative pathogenicity of F. roseum isolates to plants grown in nutrient solution culture was confirmed by inoculations of severed taproots of 4 month old red clover and alfalfa plants in soil in the greenhouse.

Title: Papilla Mechanism of Resistance of Reed Canarygrass to Leafspot Fungi

Leaders: R. T. Sherwood and C. P. Vance, U.S. Pasture Laboratory

Our studies revealed that reed canarygrass leaves have an inducible protection mechanism in which prior inoculation of the leaf with a nonpathogenic fungus can induce localized resistance to a pathogen in subsequent inoculation. Preinoculation of leaves with Botrytis cinerea reduced number of infections by the pathogen Helminthosporium catenarium. Botrytis inoculation protected against H. avenae even when the protected tissue was treated with cycloheximide to block the normal epidermal papilla formation resistance mechanism. Attempts of the pathogen to penetrate protected epidermis were thwarted by formation of lignified cell wall appositional growths (papillae) at the sites of attempted penetration.

Activity of three enzymes involved in lignification (phenylalanine ammonia lyase, tyrosine ammonia lyase and peroxidase) was heightened in protected tissues, even after subsequent treatment with cycloheximide and inoculation with a pathogen. Evidence was obtained which suggests that papilla formation may serve as a general mechanism of epidermal resistance to fungi within the grass family. Grass species representative of eight tribes of Gramineae were inoculated with Curvularia lunata. Papillae formed at sites of attempted penetration, and no penetration occurred through papillae. In tissues treated with cycloheximide, papilla formation was inhibited, and the fungus readily penetrated and colonized the tissue.

Title: Alkaloid Content of Reed Canarygrass in Relation to Disease Resistance

Leaders: R. T. Sherwood, K. E. Zeiders, and C. P. Vance, U.S. Pasture Laboratory

Clones representing a wide range of genetically controlled alkaloid concentrations were inoculated with two leafspot pathogens, Stagonospora foliicola and Helminthosporium catenarium. Resistant and susceptible clones were found among both low alkaloid clones and high alkaloid clones. Disease severity was not related to the type of alkaloid compounds (gramine vs. tryptamines) in individual clones. Infection did not alter alkaloid concentration. Incorporation of reed canarygrass alkaloids into agar media (crude extracts, and pure compounds tested at 500 ppm) gave little or no inhibition of the growth rate of these fungi. Treatment of leaf pieces with cycloheximide inhibited fungal resistance but did not change total alkaloid concentration. We concluded that indole alkaloid content of leaves is not directly related with resistance to these two fungi.

Title: Verticillium Wilt of Alfalfa Found in the United States

Leaders: J. H. Graham, USDA, Beltsville, Maryland; R. N. Peaden, USDA, Prosser, Washington; and D. W. Evans, Washington State University, Prosser, Washington

Verticillium wilt of alfalfa (Medicago sativa L.), caused by the nonsclerotial fungus Verticillium albo-atrum Reinke & Berth., has been found for the first time in the United States. The fungus was isolated from diseased plants collected in central and western Washington and north central Oregon. Laboratory inoculations with the fungus produced wilt symptoms and death of susceptible plants, while plants of resistant European cultivars were only slightly to moderately affected.

SECTION IV

GROWTH, PHYSIOLOGY, AND CLIMATIC EFFECTS

Title: Improving Biological Nitrogen Fixation in Forage Legumes and Grasses

Leader: L. D. Owens, Beltsville, Md.

A field experiment was conducted with corn, sorghum and pearl millet fertilized with four levels of N and inoculated with live or killed Spirillum bacteria. No dry matter or total plant N yield responses were obtained as a result of N fertilization or inoculation with live Spirillum. N_2 fixation (acetylene reduction) of soil cores containing part of central root system was low, variable and not associated with inoculation or N level. Numbers of Spirillum in soil-root cores taken at end of season were not increased by inoculation.

In a separate experiment corn and sorghum were grown in field-placed cylinders of ^{15}N -labelled soil inoculated with live or killed Spirillum. Analyses for dilution of isotope ^{15}N by biologically fixed $^{14}N_2$ will be performed.

Title: Effect of Supplemental Light Sources on Alfalfa Flowering and Seed Production in the Greenhouse

Leaders: J. H. Elgin, Jr. and J. E. McMurtrey III, USDA, Beltsville, Md.

We evaluated the effects of 400-W high pressure sodium, metal halide, mercury vapor, and 300-W incandescent supplemental lighting on the growth, flowering, and seed production of 6-month-old greenhouse-grown alfalfa. Light intensity measured 1 m below each lamp was 26,910, 4,305, 7,750 and 807 lux, respectively, for the four light sources. All plants were clipped at the beginning of the 9-week study. Percentage of plants blooming during the test, mean number of days to first flower, mean plant height at first flower, mean number of racemes per plant produced, mean number of flowers per raceme, and total hand-pollinated seed produced were directly related to total light supplied. The most effective supplemental light source was the high pressure sodium, where a fourfold increase in seed production over the incandescent lamp was obtained.

Title: Silage Investigations

Leaders: Milton A. Sprague and B. Brooks Taylor, New Jersey

A new method developed permits continuous monitoring of the pH of silage throughout fermentation and storage. Its use was demonstrated with data from 10 silos of orchardgrass representing three rates of nitrogen fertility and two stages of maturity. The time required (hours) for the pH to drop below 4.2 is inversely related to the efficiency of preservation. A carbohydrate to protein ratio of at least 1.5:1 is required for low dry matter and low protein losses which are indicated by a rapid drop in pH of the mass below 4.2 in from 15 to 20 hours.

Title: Effects of Soil Aluminum and Liming on Nodulation and Nitrogen Fixation in Alfalfa

Leaders: G. O. Estes and D. T. Roberts, New Hampshire

Research is being conducted on the relationship of yield, nodulation and nitrogen fixation of alfalfa to soil aluminum and liming. The primary aim of the study is to investigate the interaction of soil aluminum with the nitrogen fixation process and the effect of this interaction on alfalfa yield. In the field, studies will be conducted to examine nitrogen fixation in alfalfa under conventional and minimum tillage and with broadcast and pelleted lime. In greenhouse and laboratory experiments, different cultivars of alfalfa are being grown with concentration gradients of aluminum to study nodule development (electron microscopy) and nitrogen fixation (acetylene reduction). Future research will be centered on the infection process and the resulting fixation of nitrogen as it relates to alfalfa quality and yield.

Title: Response of Alfalfa to Sulfur

Leader: G. O. Estes, New Hampshire

Sulphur analyses of alfalfa collected in New Hampshire in 1976 show levels of 0.14-0.19% which are marginally deficient. Because S applications to agricultural land are currently very low due to the use of high analysis fertilizers, the S levels of alfalfa in New Hampshire are below the normal range of 0.20-0.45%. A project has been initiated to investigate two S sources (S and CaSO_4) at five rates on crop yield and quality under field conditions. Quality of alfalfa in terms of protein

levels is also being evaluated since N fixation of S-deficient alfalfa is restricted which lowers the content of total N. Plant tissue from all harvests will be analyzed for S and changes in tissue S between years will be studied.

Title: Physiological Changes in Corn Following Split Applications of Urea

Leaders: G. O. Estes and R. D. Marttala, New Hampshire

A field study conducted during 1976 evaluated leaf area, N recovery and yield of DM following split applications of N to no-till and conventionally prepared plots of corn. Three varieties of corn varying in maturity were also used. Each variety received the equivalent of 200 kg N/ha spread over two different stages of growth--at planting and 40 days after emergence. The N treatments were 0% (control), 100%/0%, 75%/25%, 50%/50%, 25%/75% and 0%/100%. Seedling size, leaf area and N content of young plants were much greater under conventional compared to no-till plots. At final harvest, leaf area, DM/ha and N recovery were greatest where conventional tillage was used. One year's data show that corn which received all nitrogen at planting was equal to or greater in leaf area, N recovery and yield with the other N treatments.

Title: Morphology, Physiology and Management of Perennial Forages

Leaders: Gary W. Fick, Charles Darrah, Bernard Kalu and George Maybee, New York (Cornell)

Changes in the lipid fractions of the taproots of alfalfa as they undergo cold acclimation have been under study. Three types representing different degrees of hardiness have been compared: Moapa (nonhardy), Iroquois (moderately hardy), and Medicago falcata (very hardy). The earlier reported increase in phospholipid concentrations in Iroquois during the hardening period was also found in the other types indicating that the phospholipid change is a response to hardening conditions and not an indication of hardiness itself.

To more rigorously test the quantitative associations of morphological development of alfalfa, the environment, and the quality of forage, a 10-stage system for classifying the stage of development was used on field-grown material. Each stem in a forage sample was classified and the mean stage calculated as the average stage of the stems, weighted either by count per category or dry matter per category. Warm-season

development rate was faster than cool-season development rate indicating a negative correlation of stage number and quality. Further studies are planned to evaluate the system.

Microwave radiation was tested as a pretreatment to stop respiration in forage samples to be analyzed by detergent analysis. It was found that such pretreatment could produce heat damage in the samples, and so the procedure should be used with caution.

Title: Cold Tolerance of Alfalfa, Barley, and Wheat Exposed to Continuous Soil Warming

Leaders: Gerald A. Mellish and Daniel P. Knievel, Pennsylvania

Steam and nuclear power plants eject large amounts of waste heat into the environment each year. Conventionally this heat has been transferred directly to the environment through lake and river cooling systems or wet cooling towers.

Soil warming has been proposed as an alternative method of disposing of waste heat with an added benefit of increasing crop production. In a soil warming system, heated condenser water would be circulated through a closed underground pipe network in order to warm the soil and dissipate heat. After the condenser water has been cooled it would be returned to the power plant to be reused. Several experiments have already shown that it is technically feasible to dispose of waste heat in this manner, but attempts to demonstrate that waste heat disposal systems would greatly improve crop yields have been inconclusive.

Raising soil temperatures during all or part of the year greatly alters many of the ecological factors associated with crop growth such as disease and insect relationships and plant survival mechanisms. Although soil warming may result in increased plant growth during a cool spring, it may interfere with the normal fall development of processes associated with winter survival.

In our experiment, we studied the effect of elevated soil temperature on the development and persistence of crop cold tolerance. We measured the degree of cold tolerance in alfalfa, wheat, and barley tissue at various times during the fall, winter, and spring. Our data showed that soil warming caused a delay in the development of cold tolerance in all three species and that midwinter tolerance levels in wheat and barley were less on heated areas compared to unheated areas. Reduced cold tolerance development by barley resulted in severe winter killing on the heated areas, while little or no winter killing occurred on the unheated areas. Soil warming had little or no effect on the survival of alfalfa or wheat in the winter of 1975-76.

We conclude that continuous soil warming compared to natural conditions can result in increased winter killing of moderately winter hardy crops, while little additional winter killing due to soil warming would usually occur with varieties or species capable of developing a high degree of winterhardiness.

Title: Distribution of Carbon-14 in Crownvetch Following Assimilation by Various Leaves During Seed Formation

Leaders: Daniel P. Knievel and Guy W. McKee, Pennsylvania

Crownvetch (Coronilla varia) is grown as a harvested forage and pasture crop for ruminants and for soil stabilization on poor soils, disturbed lands and steep slopes. Best seed yields are obtained where abundant moisture during the early, vegetative stages of growth is followed by relatively dry conditions. Flowers develop on peduncles arising from the axils of leaves from the middle to near the top of the indeterminate-ly growing plants. Each shoot can support approximately 10 seed producing umbels. Abundance of rainfall after flowering encourages renewed vegetative growth at the top of the canopy. Severe lodging occurs so that seed bearing umbels are shaded and poor seed development results.

The objective of this experiment was to determine the pattern of assimilate distribution within crownvetch during seed formation. Plants were pollinated to develop 4 to 5 umbels at consecutive nodes in the middle of the stem. Leaves from the top, middle, and bottom of seed bearing stems, adjacent regrowth, and umbels were exposed to $^{14}\text{CO}_2$ and harvested 8 to 10 days later. Exposed upper and lower leaves retained radioactive assimilates and exported to nearby stems and to roots, while only traces of activity moved to developing seed. Middle leaves retained only 10 to 15% total plant activity. Remaining activity was found in umbels in axils of exposed leaves, crowns and roots. Little activity moved to umbels in axils of leaves immediately above or below the exposed middle leaves. Leaves of regrowth tissue retained activity and exported to other regrowth tissue, crowns, and roots, but almost no activity moved to older stems, leaves or developing seeds. Exposed umbels retained nearly all their nonrespired activity except for 5 to 9% that was detected in crowns and roots.

Labelled carbon dioxide remained near the site of exposure or moved to crown-root tissue. Developing seed utilized assimilates fixed by the umbel itself or imported from the subtended leaf. Little movement of assimilates from one major shoot to another was observed, even though both grew from the same crown which accumulated substantial radioactivity. The lack of assimilate movement to umbels except from the subtended leaf may indicate that sufficient energy for seed development was already available or that developing crownvetch seed has limited "sink strength" to draw assimilates.

Title: Nutrient Utilization Efficiency of Crop Species, Hybrids and Cultivars

Leader: R. H. Fox, Pennsylvania

Twenty-three cultivars of seven warm-season grass species (little, big, Old World and Caucasian bluestem, Indiangrass, switchgrass and deertongue), three cool-season grasses (orchardgrass, timothy, tall fescue), and Lathco flatpea were planted in a replicated trial in a soil having very low available P (5 ppm Bray 1), with and without added P fertilizer. A blanket application of N, K and lime was applied to both treatments.

Visual ranking at the end of the growing season indicated the following cultivars to have the most vigorous growth in the low-available-P soil: all three cultivars of Old World bluestem (Bothriochloa ischaemum), the one cultivar of Caucasian bluestem (Andropogon caucasica) tested, four of the seven switchgrasses (Panicum virgatum), one of the Indian-grasses (Sorghastrum nutans), orchardgrass (Dactylis glomerata) and tall fescue (Festuca arundinacea).

The concentration of P in the low available P grown grasses ranged from 0.14 to 0.25%. The cultivars with over 0.2% P were quite small so the total P uptake in these was probably no greater than from the more vigorous cultivars. Next year these established cultivars will be harvested and examined in more detail to determine their potential yield and nutritive value in both low and high available P soil. The most efficient lines will be studied further to determine the physiological or morphological cause for this efficiency.

These cultivars were examined by a plant pathologist from the U.S. Regional Pasture Research Laboratory (K.E. Zeiders) in August. He found that there were wide differences in the amount of spotblotch disease caused by a species of Helminthosporium among seven switchgrass genotypes. On a 1-9 scale, entry means ranged from 2.3 (slight) for Ky 729 to 6.4 (severe disease) for cultivar 'Carthage 75'. Cultivar 'Blackwell' averaged 4.6; four other entries were lower than 4.6. Several isolates of the causal fungus have been obtained. Genotypes of little bluestem, big bluestem, and Indiangrass had very little leaf disease.

Leaves of timothy and orchardgrass were moderately to severely blighted in both high- and low-P soil. Curvularia lunata was isolated from blighted timothy and Helminthosporium triseptatum from blighted orchardgrass. Both of these fungi are relatively weak pathogens, and there is doubt if they were the principal cause of disease in either case. Artificial inoculation tests with the two fungi on timothy and orchardgrass are planned.

Title: Effects of Genotypes and Environments on Growth and Feeding Quality of Forages

Leader: W. A. Kendall, U.S. Pasture Research Laboratory

Studies of the characterization of root systems of forage species grown on slant-boards (Crop Sci. 14:317. 1974) were continued. The slant-board technique was modified by eliminating nitrates from the nutrient solution in order to provide plants with effective nitrogen fixing nodules. This modification makes the technique suitable for studies of interactions of fungi and insects (especially the clover root curculio) with the nitrogen fixing nodules. A gravel culture technique was used to identify genotypes of alfalfa and red clover that differed in root characteristics. The greatest differences in root weights and shoot/root ratios occurred several weeks before the flowering stage of growth, whereas the greatest differences in types of growth as estimated by root diameter and number of branches occurred near the flowering stage. To identify genotypes of alfalfa that differ in phosphorus uptake and/or accumulation about 3,000 alfalfa plants from 20 seed lots were established in gravel culture with low levels of available phosphorus. Thirty-nine plants were selected on the basis of superior plant growth in the low P medium.

Title: Studies on Biochemistry of Plant Pathogenesis

Leaders: D. L. Gustine, C. P. Vance, and R. T. Sherwood, U.S. Pasture Research Laboratory

The phytoalexin, medicarpin (3-hydroxy-9-methoxypterocarpan), has been identified in jackbean, alfalfa, and clover. Medicarpin may be an important factor in disease resistance in these plants. We previously showed that medicarpin is produced in jackbean callus tissue after inoculation with Pithomyces chartarum spores. This response is similar to phytoalexin production in noncultured plant parts inoculated with fungal parts. To study enzymes involved in isoflavonoid pathways, we assayed phenylalanine ammonia lyase (PAL) and O-methyltransferase (OMT) using ¹⁴C-phenylalanine as a substrate and S-adenosyl-[¹⁴C-methyl]-methionine as a methyl donor, respectively. Callus tissue treated with spores for 36 hr contained 28.5 µg of medicarpin per gram of tissue, fresh weight (not detected in untreated callus). PAL activity was increased twofold in treated callus when compared to untreated tissue. Callus tissue was assayed for OMT activity with several substrates; activity in treated compared to untreated callus was increased fourfold with isoliquiritigenin, threefold with daidzein and genistein, and only slightly with caffeic acid, naringenin, and apigenin. Medicarpin is probably synthesized via an isoflavonoid pathway, and PAL and OMT are part of the pathway; therefore, increased activities of these enzymes may be required for medicarpin synthesis.

Title: Alfalfa Physiology and Growth

Leaders: N. J. Chatterton and G. E. Carlson, USDA, Beltsville, Maryland

Characterization of various alfalfa genotypes indicates that a high concentration of carbohydrates in crowns and roots late in the season is a characteristic of clones that are high yielding and tolerant of frequent harvests. Similarly, clones with high yield and tolerance characteristics also had higher concentrations of inorganic phosphorus in their crowns and roots. Enzyme-nitrogen concentration in the roots of high yielding clones was twice that in low yielding ones. We postulate that the regulatory mechanisms that determine differences in yield and tolerance to frequent harvesting reside in crown and root tissues. It is apparent that both high yield and tolerance to frequent harvests can occur within the same genotype. The photosynthetic rates of 22 different alfalfa cultivars or lines were measured to determine if selection for disease and insect resistance resulted in any shift in photosynthetic potential. No change was found with selection for resistance.

SECTION V

WEED INVESTIGATIONS

Title: Biological Control of Pasture and Forage Weeds in the Northeast

Leader: S. W. T. Batra, USDA, Beltsville, Maryland

In 1976, 650 adult Rhinocyllus conicus were released at many sites in Maryland and Pennsylvania for the control of the must thistle, Carduus nutans. About 2,000 larvae of Hyles euphorbiae were released on leafy spurge (Euphorbia esula) at four sites in New York State and at one site on cypress spurge (E. cyparissias) in Virginia. A survey was continued of native phytophagous insects attacking important northeastern pasture weeds such as: hawkweeds, sow thistles, bedstraws, white cockle, ragweeds, mayweed, chickweeds, cinquéfoils and hempnettle.

Title: Herbicide Residues in and on Forages

Leaders: R. D. Hagin, D. L. Linscott, USDA, New York (Cornell)
R. F. Lucey, New York (Cornell)

As a part of a special research program for clearance of herbicides for use on minor crops, 2,4-DB-dimethyl amine and 2,4-DB-butoxyethanol and iso-octyl esters were applied to timothy at rates of 1.5 and 3.0 lb/acre. Residue samples were taken at intervals up to 52 days. At the end of 52 days from 0.04 to 0.06% of the 2,4-DB remained in the fresh forage as compared with levels immediately after applications. Ester formulations were more persistent in timothy with 0.5% to 4% remaining in and on forage after 52 days, depending on the initial concentration. Best weed control leading to most production of quality forage was with ester formulations. Chloroprotham was applied to birdsfoot trefoil for chickweed control. The residue analysis is currently underway for expected completion prior to August 1, 1977.

Title: Weed Control in Pasture and Forage Crops

Leaders: D. L. Linscott, USDA, New York (Cornell)
R. R. Seaney and R. F. Lucey, New York (Cornell)

Weed populations were assessed in three tillage systems used for establishing alfalfa, birdsfoot trefoil, crownvetch, red clover and timothy in corn stalk land. Direct drilling (power-till) in stalk land after glyphosate application resulted in less weed competition and better stands than conventional plowing, fitting, and planting. After glyphosate, the plowing operation brought numerous weed seeds to the surface, which on germination hindered forage establishment. Disking of stalks prior to power-till planting resulted in a smoother seedbed and more rapid breakdown of stalk residues. However, plants established varied little from those of the direct-tilling plots. Red clover and birdsfoot trefoil established more consistently in 1976 than alfalfa in all three systems because of abnormally wet weather and disease problems affecting alfalfa. Early and late June alfalfa establishments in 1976 were more successful than May establishments again reflecting the severe wet conditions.

On sites previously in sod, after glyphosate treatment for control of quackgrass and other weeds, alfalfa, red clover and birdsfoot trefoil establishments by conventional and minimum tillage means were compared in 1976 in Chazy, N.Y. Stands and yields of forage established by minimum tillage were inferior to those established by conventional means. Root development followed a similar pattern. Weed control was satisfactory for establishment purposes which leads to a suggestion that poor soil conditions were responsible at least in part for the relatively poor stands after power-till drilling of birdsfoot trefoil and alfalfa. There is a possibility of degradation products from decaying vegetation at the soil surface negatively affecting the young seedlings as well.

Title: Pasture Renovation: Potential of Glyphosate for Weed Control Prior to Reseeding Desirable Species

Leaders: D. L. Linscott, R. H. Vaughan, USDA, New York (Cornell)

Birdsfoot trefoil was established successfully by minimum tillage means (power-till drilling) after herbicide treatments to timothy, bluegrass, tall fescue, orchardgrass, bromegrass, perennial ryegrass and quackgrass-timothy-orchardgrass sods. Herbicides evaluated were paraquat, glyphosate at 0, 1/2, 1, and 2 kg/ha and dalapon at 0, 3, 5, and 8 kg/ha. Weed control and stand establishment were best at the highest rates for each. In control plots and those receiving lowest chemical doses, trefoil did not establish; establishment was marginal on plots receiving intermediate doses of herbicide. Plantings in early June were more successful than in early July. July establishments did not come through the winter as well.

Title: Annual and Perennial Weed Control in Corn and Forages

Leader: Nathan L. Hartwig, Pennsylvania

Fall panicum, Panicum dichotomiflorum, was effectively controlled in no-tillage field corn on a silt loam soil, 2.5% O.M. and a pH of 7.0, with simazine at 2 lb ai/acre, penoxalin at 2 lb ai/acre when applied as early as December 17 of the year before corn planting. This early application date also allowed the highest corn stands. These same treatments gave excellent fall panicum control when applied March 30, 6 weeks prior to planting, with no corn stand reduction. Penoxalin at 2 lb ai/acre applied immediately prior to planting or preemergence also gave excellent fall panicum control but reduced corn stands by 80 to 90%. Corn will be killed by penoxalin applied directly to the seed or incorporated by the fluted coulter.

Quackgrass, Agropyron repens, in no-tillage corn was not effectively controlled by glyphosate used at 1.33 lb ai/acre in the fall or in the spring when used alone. Quackgrass top kill was 85 to 90% in the spring following fall treatment and 6 weeks following spring treatment but control diminished to 7 to 12% for both treatments by the following spring. The use of atrazine at 1 lb ai/acre + simazine at 1 lb ai/acre with glyphosate at 1.33 lb ai/acre applied 10 days before planting gave excellent quackgrass top kill during the growing season but diminished to 40% by the following spring. The most permanent control of quackgrass and highest corn yields were obtained with atrazine 2 lb ai/acre applied in early spring followed by atrazine 1 lb ai/acre + simazine 1 lb ai/acre + paraquate 0.25 lb ai/acre applied 10 days before planting.

SECTION VI

MANAGEMENT AND PRODUCTION RESEARCH

Title: Response of Silage Corn to Different Rates of Lime and Starter Fertilizers Applied to an Acid Connecticut Soil

Leader: G. F. Griffin, Connecticut

Ground dolomitic limestone was applied at rates of 0, 2, 4, and 6 tons per acre to an acid (pH 4.7) Woodbridge fine sandy loam soil. On the 4- and 6-ton/acre treatments, 2 tons per acre were broadcast and plowed down, and the balance of the lime was broadcast and disked in. On the 2-ton/acre treatment, all the lime was disked in. Corn (Funk's G-4444) was planted on May 25, 1976. Starter fertilizer was applied at seeding to half the plots at a rate to supply 20, 40 and 20 lb per acre of N, P₂O₅ and K₂O, respectively. A split-plot design with five blocks was used in which the main plots were the starters. Fertilizer (15-15-15) was applied to the starter plots at a rate of 1075 lb/acre and to the nonstarter plots at a rate of 1200 lb/acre.

During June and July there were striking responses to the starter fertilizer, especially at the lower lime application rates. After harvest on October 7, however, it was found that the only statistically significant (P < .01) yield differences were between the 0 tons/acre lime treatment and all other lime levels. Yields are shown in the following table:

<u>Lime rate</u> <u>tons/acre</u>	<u>Tons/Acre Silage at 30% D.M.</u>		
	<u>No Starter</u>	<u>Starter</u>	<u>Mean</u>
0	12.5	13.2	12.8
2	15.8	16.4	16.1
4	15.7	17.2	16.5
6	16.9	18.3	17.6
Mean	15.2	16.3	15.8

Title: Response of Silage Corn to Different Rates of Urea and Sulfur-Coated Urea with and Without Starter Fertilizer

Leader: G. F. Griffin, Connecticut

Sulfur-coated urea (36-0-0) and urea (45-0-0) were applied at different rates to a Woodbridge fine sandy loam soil. Corn (Funk's G 4444) was planted on May 25, 1976. Starter fertilizer was applied at seeding to half the plots at a rate to supply 20, 40 and 20 lb/acre of N, P₂O₅ and K₂O. A split plot design with five blocks, in which starter fertilizer formed the main plots, was used.

The corn was harvested on October 7 as a silage harvest. Yield responses to starter fertilizer and rate of nitrogen were obtained but were not high enough to reach statistically significant levels. There was no response to source of nitrogen.

Title: Influence of Timing of Herbicide Applications on No-Tillage Establishment of Legumes

Leader: R. A. Peters, Connecticut

An experiment was started in the fall of 1975 on a mixed sod of Colonial bent, Kentucky bluegrass, timothy and quackgrass. Dalapon 15 lb ai/acre and glyphosate at 1-1/2 lb ai/acre were applied on November 21, 1975 and on May 14, 1976. Also on May 14 paraquat 1 lb ai/acre + X-77 surfactant was applied when the grass averaged 8-16 inches in height. On May 24 alfalfa, red clover, birdsfoot trefoil and a mixture of alfalfa and red clover were seeded with a Midland Zip-seeder.

As inspected on July 6, 1976 no sod-kill was obtained from the Nov. 21 dalapon application. Very limited response (30% stunting in height) was obtained from the fall glyphosate application. The spring treatments of glyphosate and paraquat resulted in over 95% sod top-kill as of July 6. Quackgrass was starting to regrow in the paraquat plots. Dalapon resulted in limited top-kill (50% or less).

Initial emergence and growth of the legumes in the spring-treated plots were good but the stand was somewhat erratic. This was related to the degree of sod penetration of the seeder. Penetration was greater in the glyphosate and paraquat plots than in the dalapon plots.

Notes taken on October 12, 1976 indicated that annual weeds, especially the annual grasses, yellow foxtail and witchgrass, had emerged on some of the plots with good sod-kill. This growth resulted in severe competition to the seedling legumes. The release of annual weeds from seed

which has lain dormant in sod which was completely killed poses a problem in no-tillage legume seedings. The presently labeled grass killers for new legume seedings are all preplant incorporated. An influx of dandelions, presumably seedlings, was observed in the plots with a high degree of sod-kill.

All three legume species established wherever an initial stand was obtained. No grazing or clipping was carried out the year of seeding. By October 12 the alfalfa and red clover were over 2 ft tall and were lodging. The birds-foot trefoil had produced growth comparable (1 1/2 ft tall with many tillers) to the alfalfa which is seldom the case the first season in conventional plantings. The greatest biomass was obtained from the red clover. The seeded red clover grew vigorously. The amount of clover was increased by considerable volunteer clover.

On October 15, 1976 all growth was removed and 350 lb/acre of 0-15-30 applied.

In 1977 yields will be taken and hand separations made of each component.

Title: Renovation of an Old Alfalfa Stand

Leader: R. A. Peters, Connecticut

The experimental area was an old alfalfa stand which had become quite thin and heavily infested with quackgrass and Kentucky bluegrass.

Seedlings of alfalfa (12 lb/acre), red clover (8 lb/acre) and a mixture (6 lb/acre alfalfa + 4 lb/acre red clover) were made on August 18, 1976 with three types of no-tillage seeders. They were the Midland Zip-seeder, the Bettison 3D and a Bridger corn no-tillage planter modified by using Gandy granular insecticide boxes for legume seed hoppers. On August 19 the plots were treated with glyphosate at 1 and 2 lb ai/acre or paraquat + X-77 at 1/2 or 1 lb ai/acre. The old alfalfa plants were killed by the glyphosate but with paraquat by August 30 regrowth to as much as 6 inches tall had occurred. Glyphosate treatments resulted in only a small amount of quackgrass recovery but general recovery occurred following paraquat treatments. Legume stands were erratic with red clover stands and growth rate better than with alfalfa. A good part of the erratic stand was associated with failure of the seeders to penetrate the old sod. There was no obvious difference between the three seeders.

In 1977 yields of the plots will be made based on separation of each component.

Title: Nitrogen Sources for Fertilizing Corn

Leader: W. W. Washko, Connecticut

Ammonium nitrate (prills), urea (prills), and solution nitrogen (Nitan) are being compared in a series of experiments at Storrs and at on-farm locations to measure corn silage yield responses when these materials are applied disk-in, sidedressed or topdressed. Data after 2 years of study, show no consistent trends in net yield effect between the three materials when applications are made to the soil. Cultivation at the time of sidedressing is significantly increasing yields. Cultivation X nitrogen materials effects are nonsignificant. Topdressed materials are causing foliar injury that results in eventual yield reductions. Those yield reductions are most severe with the solution nitrogen, intermediate with ammonium nitrate and insignificant with urea.

Title: Producing Dried Immature Forages as Grain Substitutes for Ruminants

Leader: R. F. Stafford, Maine

Large plots of timothy were harvested twice during 1976 for drying and pelleting studies conducted by the agricultural engineer. The first harvest, June 8, was made when the timothy was at the late-jointing stage of maturity and 25" to 30" tall. The forage was field-dried to about 58% moisture, chopped and transported to the Department of Agricultural Engineering for further drying and pelleting studies. The second harvest, July 22, was made at preboot to boot stage when the timothy was 18" to 20" tall. This was handled in the same manner as the first harvest. Samples of the forages used for drying and pelleting were stored for subsequent feeding studies by the animal nutritionist, comparing the pelleted vs. the chopped forage.

The additional seedings of alfalfa and alfalfa-clover made in 1975 for use in 1976 were completely killed due to winter injury during the winter of 1976. New seedings of alfalfa and timothy were made during 1976, and managed to produce vigorous stands for use in 1977. Excellent stands were obtained for all seedings by fall 1976.

Forage yields and stand persistence are being determined. Detailed studies of forage quality of immature harvests will be carried out by the animal nutritionists participating in this interdisciplinary project.

Title: Alfalfa Variety Trials

Leaders: N. A. Clark and J. H. McNemar, Maryland

Two variety trials were harvested in 1976. One had been established in spring 1973 and the other in spring 1976. Yields in the 1973 test ranged from 5.2 tons/acre to 3.3 tons/acre. Saranac AR and Arc were the top varieties in this test. The lowest yielding cultivars were Saranac, Team, Vernal and Spredor. The 1976 seeded trial was harvested three times. Yields ranged from 4.3 to 3.5 tons/acre with little difference among the 16 entries.

Title: Response of Alfalfa to Irrigation, Fertility, and Cutting Management

Leaders: N. A. Clark and J. H. McNemar, Maryland

The experiment was established in spring 1974 to study the effect of irrigation, fertility, and cutting management on Williamsburg and WL 311 alfalfa. Irrigation treatments consist of no irrigation and irrigation according to tensiometer readings. Fertility is maintained at one-half, double, and soil test levels. Cutting treatments are: early-bud followed by 30-day intervals, full-bud followed by 40-day intervals, full-bud followed by 30-day intervals, and half-bloom followed by 40-day intervals. Rainfall in 1976 averaged slightly over 1 inch/week, and only a slight response to irrigation was obtained. The early-bud with 30-day interval harvest yielded 6.6 tons/ha while the half-bloom with 40-day interval yielded 10.7 tons. The other treatments were intermediate. There was no statistically significant difference between the low and the medium level of fertility, but the high level yielded 9.5 tons compared with 8.1 tons for the medium level. This was statistically significant at the 5% level. Average yield for the newer cultivar, WL 311, was 9.2 tons which was significantly higher than the 7.6 tons obtained from Williamsburg.

Title: Minimum Tillage Pasture Renovation

Leaders: A. M. Decker and R. F. Dudley, Maryland

Forage yields were obtained from five species sod-seeded using four methods of soil tillage, and seed placement with glyphosate at one rate and paraquat at three rates.

During the early establishment period, red clover was the most productive and weed-free. Stands of trefoil and crownvetch were relatively weak at first but improved with time. The red clover stands were relatively short-lived while those for trefoil and crownvetch increased and were near ideal in 1976. Sod-seeding of alfalfa and tall fescue resulted in more erratic stands than other species. While glyphosate resulted in greater sod-kill, there was little difference in species establishment between glyphosate- and paraquat-treated plots. Adequate sod control was obtained with paraquat at 0.5 lb active ingredient/acre and rates above this level did not improve establishment or forage yield.

Red clover stands were slightly better with Noculimed red clover seed and first-harvest forage yields were slightly higher, especially on the low pH plots. Establishment of alfalfa was largely determined by the soil pH with little effect of Noculimed seed treatment. Soil pH was the most important factor in forage production of both alfalfa and red clover.

Title: Evaluation of Sod-Seeded Pastures Using Dairy Steers and Heifers

Leaders: A. M. Decker, J. H. Vandersall, N. A. Clark, and D. J. Under-sander, Maryland

Pastures which were heavily infested with herbaceous weeds and woody species were clipped with heavy-duty rotary mower and excess trash was removed; large trees were also removed. The area was divided into 20 0.61-ha paddocks according to vegetative cover and field condition. Three pasture treatments: (1) brush and weed removal only, (2) brush removal plus alternate row sod-seeding of red and white clover with crownvetch, and (3) brush removal plus alternate row sod-seeding of red and white clover with alfalfa were randomly assigned to uniform groups of paddocks within each of two replications. Dairy heifers and steers were used as both test and grazer animals. The put-and-take system was utilized to provide uniform grazing pressure.

Pasture carrying capacity, daily animal gains, gains per hectare, and animal condition at the end of the grazing season were increased with sod-seeded legumes. Weed population was reduced with sod-seeded legumes.

Title: Integration and Evaluation of Forage Production, Handling, and Utilization Systems

Leaders: Gary W. Fick, Carl E. Coppock, Robert A. Milligan, and Todd E. Thompson, New York (Cornell)

A new Regional Research Project has been initiated to work on the interdisciplinary problems of forage-based agriculture in the Northeast. The objectives of the project are to (1) incorporate available information about forage production, forage handling and storage, and forage utilization subsystems into an overall Forage Systems Analysis Model that may be used to systematically and quantitatively evaluate a wide range of management alternatives in dairy production enterprises, and (2) assess data deficiencies of the Forage Systems Analysis Model and to develop a research plan to provide information needed to correct the most important deficiencies.

The project includes Agronomists, Agricultural Engineers, Animal Scientists, and Agricultural Economists from about seven experiment stations in the Northeast. Standard linear programming procedures will be used to facilitate extensive economic analysis within the systems framework. All participants contribute information of relevance possessed by their units. Existing alfalfa and corn simulation models (ALSIM and SIMAIZ) and linear programs of dairy production enterprises will be used. All participants will be involved in the development of the structure of the model by critical review, particularly of those relationships and biological concepts implied which fall within the range of the disciplinary competencies. Upon completion of Objective 1, project participants will be asked to identify and define deficiencies of the models and to develop a list of experiments designed to provide information needed to correct these deficiencies. Sensitivity analysis will be used to establish the relative importance of the proposed experiments.

Title: Improvement of Birdsfoot Trefoil Seed Production Practices

Leaders: D. L. Linscott, H. M. Schaaf, USDA, ARS, New York (Cornell) and R. D. Helgeson, Department of Entomology, Cornell

Simazine-pronamide combinations applied in the fall controlled annual and perennial species in seed fields the following season. Simazine-dalapon combinations were not as effective except that contaminating red clover seed production was prevented. Metribuzin-dalapon or metribuzin-pronamide combinations were too damaging to the trefoil to be considered further. Single herbicide treatments, as opposed to combinations, were not effective over the grass and broadleaf weed spectrum.

Inoculation of 300 trefoil selections with a highly virulent isolate of Stemphylium loti revealed two genotypes with stable resistance to the fungus. Both genotypes appear to be cross incompatible. Newly-planted production seed fields were critically affected by root rot organisms in 1976. Fields out of trefoil production for at least 3 years were not reduced significantly in stand by root rots.

Six percent of the tarnished bugs collected from trefoil during October 1975 were parasitized by a roundworm, Hexameris. Subsequent survey has revealed that Lygus lineolaris adults are parasitized by juvenile worms in the spring as well as in the fall. However, it was not possible to determine whether there was one or two generations of worms per year. The rate of adult parasitism increased from the fall of 1975 to the spring of 1976 indicating that some nematodes may gain access to hosts at host overwintering sites. The nematode seems to parasitize several other hosts, including the spittlebug, Philaenus spumarius, and the lady beetle, Coleomegilla maculata.

Title: Morphology, Physiology, and Management of Perennial Forages

Leaders: Robert R. Seaney and Leon Hatch, New York (Cornell)

Forage yields and persistence of alfalfa and an alfalfa-timothy mixture were studied during 1973-76 on three different soils: Erie, somewhat poorly drained; Lima, moderately well drained; Howard, well drained. Heaving of alfalfa plants was greater on the poorly drained sites and in the clear stands of alfalfa. Encroachment of weeds was greater in clear alfalfa than in the alfalfa-timothy mixture. Total seasonal forage yields of alfalfa-timothy was greater than alfalfa on the Erie and Lima soil. On the Howard soil, yields were the same. Three harvest schedules were also compared. The schedules differed only in date of first cut, June 1, June 10, and June 20. The harvest schedule with first cut on June 1 resulted in highest total forage yield, greatest loss of timothy stand, and the most severe encroachment of dandelions. Companion studies were initiated to determine the reason for dandelion encroachment and the effect of dandelions on yield and persistence of alfalfa.

Title: Development of Seeding Techniques and Management Systems for Feed Crops in Southwestern Pennsylvania

Leader: William G. Downs, Pennsylvania

Kenstar red clover alone or with timothy produced 3/4 ton/acre more hay than the Pennscott variety alone or with timothy. Grasses alone with 50/50 lb N/acre produced more forage than alfalfa and birdsfoot trefoil alone or these legumes in grass combinations. The nine N-fertilized grasses produced an average of 3.6 tons of hay/acre in two cuttings. Six alfalfa varieties alone averaged 3.1 tons/acre of hay, whereas four birdsfoot trefoil varieties averaged 3.5 tons of hay/acre. Two alfalfa-grass mixtures yielded only 2.76 tons of hay/acre, whereas eight birdsfoot trefoil-grass mixtures averaged 3.45 tons/acre of hay. N-fertilized reed canarygrass outyielded all other forage species alone or in legume-grass mixtures with 4.95 tons/acre of hay.

Similarly, Empire birdsfoot trefoil-Climax timothy surpassed all legume-grass mixtures with a hay yield of 4.0 tons/acre. When grown alone WL311 alfalfa was most productive of forage among the alfalfas, whereas the variety Viking excelled the other three birdsfoot trefoil varieties in forage production.

Title: Long-Term Effects of Variations in Soil and Crop Management Systems

Leader: Lynn D. Hoffman, Pennsylvania

This study, established in 1969, investigates effects of three lime-fertilizer treatments and five cropping systems. Since 1975 the fertility treatments include (1) soil test recommendations for each crop, (2) same as 1 but no phosphorus and (3) same as 1 but no lime. The cropping systems are (1) continuous corn, (2) corn-soybeans, (3) 1 year corn, 2 year alfalfa, (4) 2 year corn, 3 year alfalfa and (5) corn-oats-wheat 2 year alfalfa. All possible combinations occur each year in 192 plots.

Soil pH levels in fertility treatment 3 have dropped as low as 5.4. Alfalfa plots are significantly lower both in yield and quality of forage than the other treatments. Lower pH in this treatment is causing poorer weed control in corn. Following is a summary of crop yields by cropping systems for the 6-year period 1970-1975.

Corn: 130.4, 134.0, 142.4, 140.2 and 142 bushels/acre for cropping systems 1, 2, 3, 4, and 5, respectively. Soybean yields for the period were 32.0 bushels/acre. First-year hay yields were 2.12, 2.19 and 4.31

tons DM/acre for cropping systems 3, 4, and 5, respectively. Second year of establishment hay yields were 4.7, 4.7, and 4.89 tons of DM for cropping systems 3, 4, and 5, respectively. Third-year hay in cropping system 4 averaged 4.95 tons DM/acre. Oat yield averaged 68 bushels/acre for the same period. Wheat yielded 4.78 tons/acre from 1970-1975. These yields show the response to cropping system averaged across all three soil fertility treatments.

Title: Productivity and Quality of Fertilized Perennial Forages

Leader: L. F. Marriott, Pennsylvania

The fertility work on the 1970 seeding of crownvetch was discontinued in 1976. Grass and weeds were continuing problems and there was no differential response to fertility levels.

Crownvetch has been grown in association with orchardgrass, smooth bromegrass, tall fescue and timothy since 1972. The crownvetch has persisted well, but the stand has not increased since the establishment of the various fertility regimes. Where only P and K have been applied, the proportion of crownvetch in the first harvest was about 15%, and about 35 to 45% in the second harvest. Applications of 50 lb N/acre in the spring and/or after the first cut increased grass production and resulted in a reduction of the crownvetch proportion to about 8 to 10% in each harvest. Where N was applied only in the spring, crownvetch contributed about 20% of the forage in the second harvest. When grown alone, orchardgrass, bromegrass and timothy fertilized with 50 lb N/acre produced as many pounds crude protein as the equivalent crownvetch grass association. Tall fescue required 100 lb N/acre to do the same.

Liquid dairy manure was topdressed on the forages at 100 lb N/acre in the spring, and in the spring plus an additional 78 lb N/acre after the first cut. The manure N was 40 to 50% as effective as N applied as urea.

Title: Establishment and Management of Several Grass and Other Species for Forage Ground Cover

Leader: J. B. Washko, Pennsylvania

Obtaining a stand of the warm-season grasses has been a major problem under Pennsylvania conditions. Switchgrass, Panicum virgatum, appears to hold more promise for forage production than big bluestem and little bluestem. Weekly seedings of the Blackwell variety of switchgrass were

made from April 14 through July 26, 1976. Two seeding implements were used on each date, a grain drill equipped for band seeding with packer wheels and a corrugated roller seeder. Successful seedings were established for all seeding dates. Emergence of seedlings was faster when seedings were made with the band seeding grain drill with the packer wheels. Summer weeds were a serious problem in plantings made from April 14 through May 24.

Title: Effect of Management Factors on Alfalfa Productivity and Persistence

Leaders: J. B. Washko and K. T. Leath, Pennsylvania and U.S. Pasture Research Laboratory, respectively

Twenty-seven alfalfa varieties were harvested for the fourth year in the alfalfa dehydration area of Lehigh Valley of Pennsylvania. Yield differences among 17 varieties were statistically nonsignificant, ranging from 4.48 to 4.84 tons of dry matter/acre over the 4-year period. In 1976, the fourth harvest year, these 17 varieties still produced from 5.33 to 6.12 tons/acre of dry matter under a four-harvest/year system. The four most productive varieties were resistant to southern anthracnose, a most destructive disease and were: Waterman-Loomis 219, WL 311, WL 309 and Arc. These varieties averaged 13.1% higher in yield over the 4-year period than the standard variety, Buffalo, commonly seeded by the dehydrator. In a four-variety fertility experiment in Lancaster County the highest yielding variety, Saranac-AR, also carried resistance to southern anthracnose. In a fertility experiment under dehydration harvest conditions on a Duffield silt loam, highest alfalfa yields were obtained where two increments of potash, 150/150 lb/acre were applied annually, one as a fall application, the other after removal of the first cutting. This annual split application of potash increased dry matter yields by 21% over the check plot and 6.7% over a 450 lb/acre application of K₂O made at seeding time. Alfalfa stands were also maintained best under the annual split applications of K₂O. No P₂O₅ yield response was obtained on this soil type.

Title: Beef-Forage Management Practices

Leaders: J. B. Washko, L. L. Wilson, D. D. Fisher and R. A. Peiffer, Pennsylvania

Two-year-old pastures sod-seeded to the following grasses alone and with Viking birdsfoot trefoil, Pennmead orchardgrass, Sac smooth brome grass

and Ky 31 tall fescue were compared under cow and calf grazing conditions. In addition to P₂O₅ and K₂O fertilization of all species according to soil test the grasses alone were topdressed with four increments of nitrogen (50/50/50/50 lb/acre), the first increment prior to the first grazing and one increment after each successive grazing except the last. Pasture paddocks were 5.5 acres in size located on Hagerstown and Hublersburg silt loams with each species or mixture replicated twice and were grazed with 20 Charolais cows, their calves and a bull.

The N-fertilized grass pastures were superior to the birdsfoot trefoil-grass pastures in carrying capacity. The N-fertilized grass system furnished 129 days of grazing per acre with 95 days for the trefoil-grass pastures until mid-August when the experiment was terminated. In addition the N-fertilized grass system furnished 2.0 tons per acre of hay on one of the three paddocks allocated to the N-fertilized grass system. Both the N-fertilized grass and legume-grass carried 20 cows, their calves and a bull from May 10 to June 24, 1976. After the latter date the N-fertilized grass paddocks carried the same number of animals (bulls were removed at the end of the breeding season) but cow and calf numbers had to be adjusted downward on June 24 to 14 cows and calves and on August 3 to 10 cows and their calves because of the limited forage production on the trefoil-grass pastures.

These results indicate equal numbers of grazing animals can be carried on both N-fertilized grass and legume-grass swards during the "flush grass growth" period of the spring season but the N-fertilized grass swards will carry more animals for longer periods when precipitation is not limited.

Title: Evaluation of Permanent Pastures for Species Composition, Yield, Ground Cover, Grazing Pressure and Other Management Practices

Leaders: Barton S. Baker and Roger L. Nestor, West Virginia

Studies on permanent pastures previously reported (1975 Report, p. 46) were continued. Kentucky bluegrass (Poa pratensis L.), meadow fescue (Festuca elatior L.), redtop (Agrostis alba L.), timothy (Phleum pratense L.), orchardgrass (Dactylis glomerata L.), and white clover (Trifolium repens L.) were found in over 90% of the pastures surveyed. Redtop was estimated to be providing 16 to 18% of the total forage produced in the pastures which was more than any other species. Thirty grass, 12 legume, and 79 weed species were present in the 41 pastures surveyed. It was estimated that about 950 kg of forage were available per hectare in early summer and about 500 kg per hectare were available in late summer. Some pastures were overgrazed and some were undergrazed. Ground cover was estimated to be 90-95% but varied from less than 50% to near 100%. There was little difference in ground cover at the lower

grazing pressures but ground cover decreased when grazing pressure was excessive. Pasture conditions are also being evaluated in relation to soil fertility and management.

Title: Effects of Cutting and N Fertilization Management on Yield and Quality of Tall Fescue in Winter

Leader: John A. Balasko, West Virginia

Regrowth of tall fescue forage was harvested last in summer or fall on 1, 15 or 30 September. Regrowth then accumulated from these dates until 15 February at four levels of N-0, 75, 150, and 225 kg/ha. In vitro dry matter digestibility of forage harvested 15 February increased with each added increment of N for each last harvest date. Forage IVDMD ranged from 49.6 for plots cut last on 1 September and receiving no N to 70.1 for plots cut last on 30 September and receiving 225 kg/ha of N. Yield of digestible dry matter was highest (1.50 Mtons/ha) when 150 kg/ha of N was applied 1 September. Nitrogen not utilized for fall regrowth promoted early spring growth on a silt-loam soil.

Title: Production of Fodder Brassicas and Fodder Beets

Leaders: V. Ulrich and S. E. Palmer, West Virginia University; G. A. Jung, U.S. Pasture Research Laboratory

Four fodder beet varieties (Polyaurea, Peramona, Betat and Blanca), two fodder kales (Midas and Tema), one rape (Fora) and one turnip variety (Rova), all of European origin, were established on the Reedsville Experimental Farm (elev. c 1900) by hand broadcast seeding in late May. Fertilizer was applied at a rate of 82.4 lb N, 60 lb P and 60 lb K.

Rape and kale were sufficiently competitive in their growth so that weed competition did not pose a serious problem. However, the fodder beets and turnip became severely infested by pigweed, lambs-quarter and nut grass and hand weeding was made in early July to give these species a competitive advantage. Broadcast seeding without chemical weed control does not appear to be a viable culture system.

All the rape and kales were harvested in late September and produced 5.6 tons and 3.7 tons of dry matter (5.5% moisture) per acre, respectively. The dry matter yield of the beet varieties ranged from 3.7 to 6.8 tons. The turnip variety, Rova, produced 4.6 tons per acre.

Mineral analyses of the leaves and roots of beets and turnips revealed that the P, K, Ca, Mg, Cu, B, Al and Zn content were within the usual mineral range of forage grasses and legumes. However, the leaves of beets were high in K ($\bar{x} = 4.46\%$), Mn ($\bar{x} = 184.4 \mu\text{g/g}$) and Na ($\bar{x} = 3255.4 \mu\text{g/g}$). The crude protein content for the various varieties were: beet leaves 11.25%, roots 4.14%, turnip leaves 19.61%, roots 10.37%, rape leaves 26.2%, petioles 9.3%, stem 10.0%, kale leaves 25.8%, petiole 9.9%, stems 10.1%. The IVDMD percentage for beets and turnips are respectively: leaves 79.49, roots 82.05, leaves 80.69, roots 82.78.

SECTION VII

ENGINEERING RESEARCH

Title: Enzymatic Methods in Alfalfa Protein Recovery

Leaders: R. E. Mudgett and R. Rufner, Massachusetts

Investigation of in vitro enzymatic methods for enhancing cell rupture in alfalfa protein recover is continuing. Significant increases in protein recovery above levels obtained in mechanical extraction have been obtained for cellulase, pectinase and phospholipase. The effect of these enzymes on alfalfa structure is being studied by electron micrographs.

Title: Solid-State Fermentation Feasibility

Leaders: R. E. Mudgett and R. Rufner, Massachusetts

A preliminary feasibility study sponsored by NSF of a solid-state fermentation process for enhancing alfalfa protein recovery has been completed for several cellulase-producing strains of fungi obtained from the Natick Laboratories culture collection and for laboratory isolate. Results show in vivo cellulase recovery levels comparable to those obtained in vitro but at low moisture contents and water activities.

Title: Solid-State Fermentation Processes in Plant Protein Recovery

Leaders: R. E. Mudgett and P. L. Pellett, Massachusetts

An investigation of solid-state fermentation processes in plant protein recovery has been initiated. Preliminary results have been obtained in biochemical and nutritional analysis of alfalfa protein extracts with respect to endogeneous protease activity, molecular weight distribution, nucleic acid contents and amino acid composition. Effects of various unit operations in alfalfa processing are also being evaluated and utilization of alfalfa processing wastes is being studied.

Title: Protein for Human Food from Alfalfa

Leader: L. F. Whitney, Massachusetts

Protein yields from alfalfa for human food have been disappointingly low. The desirable white protein is cytoplasmic with little chloroplast protein available because of color and bitter taste. Our efforts this year have been to investigate methods of increasing protein yields from the chloroplastic components.

N-Butanol extraction of alfalfa chloroplasts and solubles yielded 30 lbs. of colorless, tasteless protein concentrate powder with PER 1.2. Heat coagulation of the juice and spray drying of powder are suspect in tying up lysine. Maceration by fixed plate attrition mill and disk centrifuging of chloroplast-laden butanol, water and protein concentrate streams are reported herein for the first time. Imbibition was investigated in conjunction with expression with an increase of protein release from 50 to 70%.

Title: Processing Dried Immature Forages as Grain Substitutes for Ruminants

Leader: R. J. Rowe, Maine

Immature forage samples from first and second cutting timothy plots were subjected to differential temperature treatments at 60 and 140 C. These samples will be split and one-half milled and pelleted before nutrient analysis.

Similar analysis of alfalfa samples harvested in 1975 indicated a decrease in availability of protein for both pelleted and chipped forms when dried at the higher temperature. Acid detergent fiber-nitrogen was higher for forage dried at 140 C than for that dried at 60 C.

A large plot sample, of about 1000 pounds, was harvested and processed for nutritive analysis and preliminary sheep digestion trials.

Follow-up on the batch drying study using solar heated air has led to development in conceptual form of a harvest and drying system where an air inflated solar collector serves as both a weather shelter and source of heat for drying.

Work is continuing on the processing, by grinding and pelleting, of immature forage samples for nutritive analysis and digestion trials to be conducted by Animal Science.

Data are being collected and refined for use in describing a processed immature forage as one of the alternatives included in a comprehensive Forage Systems analysis model being developed as part of the effort of Regional Project NE-111.

SECTION VIII

NUTRITIVE EVALUATION AND UTILIZATION

Title: Growth and Physiological Parameters of Ruminants Grazing on Different Varieties of Fescue Pasture

Leaders: James Bond and J. B. Powell, USDA, Beltsville, Maryland; and D. J. Undersander, University of Maryland, Maryland

Fescue grazing studies were conducted to correlate differences in plant chemical and structural characteristics to the growth, physiology and health of steers. Average daily gain, gain/ha, animal condition and hair coat scores were lowest for steers which grazed an experimental variety of tall fescue characterized as having a low level of the alkaloid perloine (K307) when compared to steers which grazed paddocks sown to KY31, Kenhy and another experimental variety containing a high level of perloine. Steers grazing K307 showed signs of emaciation, elevated respiration, remained under shade and stood in any available water most of the daylight hours. These signs became apparent within two weeks and persisted throughout the first 140 days of the grazing period. During the last 28 days (cooler weather) the steers grazed the K307 at the same time of day and intensity as the steers on the other varieties and gained at the same rate.

Title: Effect of Corn Stover Silage Diets Supplemented with Nitrogen from Poultry Excreta on Dry Matter Intake and Growth of Yearling Dairy Heifers

Leaders: J. E. Keys and L. W. Smith, USDA, Beltsville, Maryland

Four complete diets (1) 52.7% corn stover:38% chopped whole ear corn:9.3% fresh caged laying hen excreta (FPE) on dry matter basis, (2) 95.2% whole corn plant:4.8% soybean meal, (3) 90% whole corn plant:10% FPE, and (4) 67.5% corn stover:20.2% chopped whole ear corn:12.3% FPE were stored for 45 days above ground in completely sealed .02 cm plastic

bags 2.4 M wide x 16.8 M long. The resulting silages are now being fed to meet N.R.C. dry matter intake requirements for growth to four groups of 7 yearling Holstein heifers. Trace mineralized salt with vitamins are supplied ad lib. Heifers are housed in an open free stall shed and fed individually via electronic feedgates.

Title: Effect of Stocking Density on Weight Gains of Yearling Heifers Fed a Grass-Legume Silage:Concentrate Complete Feed

Leaders: J. E. Keys and R. E. Pearson, USDA, Beltsville, Maryland

The second of two trials in this series has been completed. It consisted of four consecutive 45-day periods and two adjacent lots (free stall and loose housing) of yearling heifers. Each period the animals were rerandomized to the following size groups:

<u>Period</u>	<u>Free stall</u>	<u>Head/free stall</u>	<u>Loose housing</u>	<u>Sq meter space under roof/head</u>
1	15	1	15	4.5
2	15	1	24	2.8
3	24	1.6	24	2.8
4	24	1.6	15	4.5

Both housing systems contained a 167 square meter exercise lot and 67 square meters under roof. The free stall system contained 15 free stalls. Both lots of heifers were fed the same ration (grass-legume silage:dry fresh grain in a 5.5:2 DM ration) at the same rate/head per period (NRC requirements - DM/kg body weight). Feed bunk size was maintained at 41 cm/head throughout the trial. A model including period, treatment, location, location x treatment, and the regression on initial body weight was used to analyze the average daily gains data.

The least square average daily gain means for periods 1, 2, 3, and 4 were 1.24, .26, .71, and .61 kg/day per head respectively (P <.001). Differences in weight gain between periods could not be explained by either ambient temperature or dry matter intake differences during the trial. The average of maximum and minimum daily temperatures for periods 1, 2, 3, and 4 were 11.6, 3.4, 4.0, and 4.6 C. Daily dry matter intakes for periods 1, 2, 3, and 4 averaged 7.3, 7.6, 7.4, and 9.0 kg/head.

The least square average daily gain means for free stall system, loose housing system, free stall 15, free stall 24, loose housing 15, and loose housing 24 groups were .70, .71, .70, .69, and .74 kg, respectively. The differences were not significant.

Title: Rumen Microbes in Heifers Fed Hay, Silage, or Concentrates
Ad Libitum

Leaders: L. L. Slyter, D. L. Kern, and G. A. Varga, USDA, Beltsville, Maryland

Samples were collected from rumen fistulated Holstein heifers (565 ± 35 kg) after ad libitum feeding with either orchardgrass hay (H), orchardgrass silage (OS), corn silage (CS) or all-concentrate corn-based (C) diets (4 x 4 Latin square) for 2 or more weeks. The rumen digesta contained the following bacteria ($10^8/g$) for H, OS, CS, and C, respectively: viable, 15, 20, 26, 93; lactobacilli, 0.07, 0.3, 0.3, 7.2; cellulose hydrolyzers, >7.4, 4.6, 1.9, <0.6; and urea hydrolyzers, 0.7, 0.1, 0.9, 7.4. Lactic acid, veillonella, and mannitol roll tube media for selection of lactic acid utilizing bacteria, Veillonella sp., and S. ruminantium resulted in bacterial counts of 1.3, 0.9, 2.2, 2.4; 0.0014, 0.035, 0.069, 0.63; and 1.3, 1.3, 1.2, and $13.3 \times 10^8/g$. Lactic agar medium, deleted of agar and adjusted to pH 6.7, had counts of 0.08, 0.17, 0.05, and 13.2×10^8 bacteria/g rumen contents; and same medium adjusted to pH 5.0 had counts of 0.0012, 0.018, 0.002, and 6.6×10^8 bacteria/g for H, OS, CS, and C, respectively. At the highest dilutions in the pH 6.7 lactic broth a spiral-shaped rod with enlarged sections at regular intervals was noted in OS and CS. S. ruminantium and M. elsdenii were found consistently in fluids inoculated into lactic broth from H, OS, CS, and C. The rate of lactic disappearance did not closely mimic differences in numbers of bacteria capable of growth in lactic broth. With strained rumen contents, about 13, 28, 71, and 59% of the supplemental 35 μ M lactic acid per ml disappeared within 4.5 hr from in vitro incubations with H, OS, CS, and C fluids, respectively. For heifers fed H, OS, CS, and C, feed intakes (kg/d), rumen digesta (kg), and rumen digesta DM (%), were 9.4, 9.9, 9.6, 8.9; 46, 58, 44, 49; and 12, 11, 12, 10, respectively. Except for heifers fed OS, some difficulty in maintaining consistent feed intake was experienced, especially when diets were changed from H to C; this difficulty occurred even though the rumen population was already adapted to C.

Title: Effect of Added Carbohydrates on In Vitro Cotton Cellulose Digestion by Bovine Ruminal Fluid

Leaders: M. E. Simpson and P. B. Marsh, USDA, Beltsville, Maryland

Twenty-eight potential carbon sources for growth of ruminal micro-organisms, mostly carbohydrates and chemically related materials, were added singly at .05-1% to ruminal fluid already containing 2% of high grade cotton fiber as a source of cellulose. The ruminal fluid was obtained from fistulated steers fed on an orchardgrass diet. After incubations at 39 C for 24, 48,

and 72 hr, pH values were obtained on the ruminal fluid, and the residual dry weight of cotton fiber was determined as a measure of cellulose digestion. Ethylene glycol, alpha methyl d-glucoside, and erythritol caused little, if any, change in the amount of cellulose digested (weight losses with 1% amendment were 87-96% of unamended control). Glycerine, pectin, and dulcitol caused moderate decreases in the amount of cellulose digested (weight losses with 1% amendment were 52-66% of unamended control). All other added carbon compounds, most of them generally considered to be highly fermentable, caused major decreases in the amount of cellulose digested (weight losses with 1% amendment were 0-40% of those in the unamended control). This latter group, listed in order of increasing effect on cellulose digestion at the 1% amendment level, included rhamnose, sodium tartrate, potato starch, fructose, sucrose, inulin, d-glucosamine HCl, sorbitol, glucono-lactone, corn starch, manitol, beta methyl d-glucoside, cellobiose, glucose, melibiose, d-xylose, arabinose, raffinose, maltose, lactose, dextrans, and mannose. Most of the added carbon sources that decreased cellulose digestion did so even at lower amendment levels than were required to decrease pH. The data suggest that the fermentable compounds able to decrease cellulose digestion in the rumen may be more numerous than the few previously mentioned in the literature.

Title: Dehydrated Caged Laying Hen Excreta (DPE) as a Nitrogen Supplement for Lactating Dairy Cows

Leaders: C. C. Calvert and R. L. King, USDA, Beltsville, Maryland

Four groups of six lactating Holstein cows were fed the following grain concentrate mixtures: 1) corn-soybean meal - 2.0% urea; 2) corn-soybean meal - 17.2% DPE; 3) corn-soybean meal - 26.0% DPE; and 4) corn-soybean meal. All concentrate mixtures were isonitrogenous containing on a dry matter basis an average of 24% crude protein. The concentrate mixtures were fed with corn silage with 50% of the dry matter provided from concentrate and 50% from silage. Silage and concentrate were mixed at the time of feeding. The experimental rations were fed from the 12th through the 44th week of lactation. Average daily dry matter intake and milk production for the 32-week experimental period were: 1) 18.4, 15.1; 2) 18.4, 18.0; 3) 18.6, 16.7; and 4) 18.1, 17.2 kg, respectively. Copper, iron, and zinc contents of milk from cows were: 1) 0.82, 4.00, 21.5; 2) 0.61, 4.22, 27.17; 3) 0.71, 4.54, 23.69; and 4) 0.68, 4.35, 26.52 µg/g dry milk, respectively. The four dietary treatments had no effect on either milk composition or flavor. Current cost per metric ton of each of the four concentrate mixtures was: 1) \$133, 2) \$125, 3) \$119, and 4) \$138.

Title: Nutritive Evaluations of Animal Excreta and Cellulosic Crop Residues for Ruminant Feed

Leader: L. W. Smith, USDA, Beltsville, Maryland

Forty-seven lambs (initial wt 27.8 kg) were randomly assigned to four treatments and fed complete-pelleted diets containing corn stalks (C) or wheat straw (W) as fiber sources supplemented with either dehydrated poultry excreta (E) or urea (U). The four diets - CE, CU, WE, and WU were balanced with corn meal and minerals and formulated to contain 70 TDN, 1.8 N, .36 Ca, and .24% P. The nitrogen supplements averaged 35% of total dietary nitrogen. In a growth trial, 6 lambs were individually fed and 6 were group-fed for 60 days. Gains were measured on all lambs for the first 45 days. Nutrient digestibilities were determined on 3 of 12 lambs on each diet during the last 10 days of the feeding trial by total excreta collection. A finishing trial was conducted with the same 47 lambs for an additional 60 days. Ground ear corn replaced the two fiber sources and was supplemented with either E or U. The two diets were formulated to contain 77 TDN, 1.8 N, .37 Ca, and .23% P. The nitrogen supplements averaged 20% of total dietary nitrogen. Fiber source in growth diets resulted in main effect differences ($P < .01$) in digestibility (%) of OM (C, 56 vs W, 62); cell walls (C, 28 vs W, 34); nitrogen (C, 53 vs W, 56), but N retentions were not different. Nitrogen source in growth diets resulted in main effect differences ($P < .05$) in digestibility (%) of OM (E, 64 vs U, 55) and N retention (E, 6.2 vs U, 2.4), but digestibilities of cell walls (31) and nitrogen (54) were not different. In the finishing trial, digestibilities of cell walls were higher ($P < .05$) (E, 40 vs U, 27) in the diet supplemented with E. Total gains averaged 146 g/day and were not different because of individual or group feeding. Gains averaged 91 g/day in the growth vs 201 g/day in the finishing trial ($P < .01$). Fiber source in growth diets affected ($P < .01$) ADG (C, 74 g vs W, 108 g) and DOM available for growth, kg/day (C, .159 vs W, .293). Nitrogen source also affected ($P < .01$) ADG (E, 176 g vs U, 70 g) and digestible OM available for growth, kg/day (E, .372 vs U, .080). Lamb performance was not influenced by nitrogen source in finishing diets. E was more efficient than U in high fiber diets for lambs.

Title: Ruminant Digestion of Energy and Protein

Leaders: D. R. Waldo, H. K. Goering and W. E. Wheeler, USDA,
Beltsville, Maryland

Eight lactating Holstein cows were fed corn silage and corn grain based complete mixed rations consisting of a 60:40 forage-to-concentrate dry matter ratio and containing either .14 or 2.74% added limestone buffer. Digestion coefficients were (%): dry matter 66.1, 69.5; energy 65.7, 69.0; starch 85.9, 94.6; cell wall 51.3, 55.1 and crude protein 65.7, 67.8. The use of limestone as a buffer improved the digestibility of dietary dry matter due to more favorable gastrointestinal tract conditions for the utilization of both dietary starch and cell wall.

Direct-cut alfalfa was ensiled without or with 7.5% corn meal on a wet basis to evaluate energy recovery and heifer growth. Energy recovery was not consistently improved. The alfalfa silage which contained no corn meal resulted in equal or improved heifer growth when fed with 7.5% corn meal compared to the alfalfa corn meal silage.

Title: Utilization of Digestible Energy in Cattle

Leaders: H. F. Tyrrell and P. W. Moe, USDA, Beltsville, Maryland

Two experiments show that abomasal infusion of glucose improved the utilization of acetic acid infused into the rumen of cattle consuming a high forage diet. In one experiment, infusion of 1.3 Mcal of acetic acid and glucose alone or both simultaneously increased ME .76, .96 and 2.30 Mcal and energy balance -.01, .70 and 1.22 Mcal. Infusion of 1.7 rather than 1.3 Mcal in experiment two resulted in .58, .76 and 2.34 Mcal ME and -.72, .01 and 1.18 Mcal of tissue energy.

Two experiments have shown the combined effect of paraformaldehyde treatment of orchardgrass at time of ensiling and supplementation with protein at the time of feeding has no effect on energy utilization but improves use of nitrogen for growth.

Treatment means adjusted to equal GE of 337 Kcal/kg^{.75} listed in the order control, control plus casin, treated, and treated plus casein were: DE 222, 226, 220 and 226 Kcal/kg^{.75}; ME 182, 184, 182 and 187 Kcal/kg^{.75}; nitrogen intake 103, 123, 104 and 125 g; insoluble nitrogen 32, 48, 43 and 59 g; digestible nitrogen 65, 83, 62 and 80 g; and nitrogen balance 4, 14, 21 and 26 g.

Title: Effects of Grinding and Pelleting on the Nutritive Value of Complete Dairy Rations

Leader: W. E. Wheeler, USDA, Beltsville, Maryland

Estimated rates of digestion for the following ground (23 mm) forages: (a) orchardgrass hay, (b) barley straw, (c) corn stalks and (d) cottonseed hulls were obtained by the dacron bag technique with cannulated steers. Potential digestibilities (% digested after 72 hours) for dry matter and cell wall were: 68.5, 70.3, 53.8, 58.2; 42.9, 44.2; 31.0, 33.1. Rates of digestion of potentially digestible material (%/hr) were: 5.24, 5.11; 4.49, 3.79; 2.73, 3.14; 3.87, 4.32. The lowest potential digestibility was obtained with cottonseed hulls while corn stalks had the slowest rate of digestion.

Title: Utilization of Forages and Crop Residues by Beef Cattle

Leader: D. A. Dinius, USDA, Beltsville, Maryland

The differences in voluntary consumption of low-quality roughages of similar digestibility and the basis for these differences were studied. Steers consumed more cottonseed hulls than ground straw, corn stalks or orchardgrass hay even though the hulls were least digestible. Amount of total ruminal digesta was lower for steers fed hulls than those fed the other roughages, but digesta dry matter was considerably higher; thus accounting for the higher intake of hulls. Rate studies indicate that the potentially digested fraction of these roughages was digested at similar rates, but that total digestibility differed.

Methods of processing a low-quality roughage were studied in an effort to improve intake and digestibility. Straw was chopped, pelleted, blended with water and ensiled or blended with a sodium hydroxide solution and ensiled, and then subsequently fed to steers to determine digestibility and intake. Pelleting increased intake but decreased digestibility, ensiling had little effect on digestibility but decreased intake, whereas ensiling or pelleting after hydroxide treatment increased both digestibility and intake. The various treatments had little effect on ruminoreticular fill or digesta dry matter. Steers apparently consumed the straw to a constant ruminoreticular fill and the higher intake of hydroxide treated straw resulted from the increase in digestibility.

Title: Corn Stover and Other Low Quality Forages for Growing Dairy Animals

Leader: J. H. Vandersall, Maryland

The work with the utilization of stover and timothy hay has continued with four short trials. Yearling Holstein heifers and steers were individually fed their forages ad libitum and concentrates were limited to 1.36 kg per head per day. The concentrate was a mixture of corn and soybean meal with salt and dicalcium phosphate and each concentrate was designed to give a total ration protein level of 11%. The work this year was designed¹ to test the effect of hay to stover ratios and the effects of elfazepam¹ on forage intake and growth.

The first 8-week trial was described in last year's report and was a comparison of alfalfa hay to stover ratios of 1:2, 1:1 and 2:1. As the amount of stover increased the feed intake and gain was decreased. The average daily gains for the animals were 408, 513 and 653 grams, respectively.

In the second trial (46 days), 6 steers and 9 heifers were grouped into trios and randomly assigned to receive 0, 6 or 12 mg of elfazepam per head daily. The forage was one-half stover and one-half timothy hay. The average forage intakes were 4.3, 4.3 and 4.8. The average daily gains were 470, 406 and 577 grams, respectively.

In a third trial (51 days) the animals were paired and assigned to receive 0 or 12 mg of elfazepam daily. Timothy hay was the only forage fed during this trial. The average daily hay intakes were 8.2 and 7.9 kg. The average daily gains were 838 and 950 grams.

In the fourth trial (63 days) one-half corn stover and one-half timothy hay was fed. The average daily forage intakes were 5.0 and 4.9. The average daily gains were 395 and 422 grams per day for the control and treated groups respectively.

This work has shown that when animals are limited to 1.36 kg of grain per day, corn stover cannot be used at levels higher than one-third of the forage diet if the heifers are to gain satisfactorily. However, none of the heifers appeared stunted by the level of intake they received when receiving up to two-thirds of the forage diet as stover. By feeding 12 mg of elfazepam per day, the animals generally gained at a faster rate and showed a better feed gain ratio, however, these differences were not statistically significant.

¹ Our thanks to Smith-Kline Corporation, Philadelphia, Pennsylvania, for supplying the additive, elfazepam.

Title: Feeding Dried Immature Forages as Grain Substitutes for Ruminants

Leader: W. P. Apgar, Maine

Small-plot samples of legume and grass forages have been harvested at immature stages under the agronomic phase of this project. Laboratory analysis of these samples is currently in progress to assess their nutritive composition. In vitro digestibility will also be used to screen the samples for the most promising immature forage treatments to be selected for evaluation in animal digestion trials. Analyses to date of immature alfalfa samples subjected to different handling procedures indicate no compositional differences between pelleted vs. chopped forage. However, an increase in artificial drying temperature from 60 C to 140 C resulted in approximately 42% increase in the proportion of total nitrogen bound in the fiber fraction (ADF-N) of the forage, thus reducing nutritional availability of the plant nitrogen. Data from these immature forage studies will contribute to the regional objective of identifying key physical and chemical factors influencing forage intake and digestibility.

Title: Effects of Calcium Supplementation to All Corn Silage Ration on Cow's Rumen Fermentation

Leader: H. Fenner, Massachusetts

Feeding trials of 4 x 4 latin square design with rumen fistulated Holstein cows were used for determining the effects of supplementing 0g, 90g, 180g and 270g of calcium hydroxide on rumen fermentation pattern. The calcium to phosphorus ratio of the diet was 1:1, 4:1, 7:1 and 10:1. Supplement and ration were combined just prior to feeding and offered in portions of 1/3 and 2/3 according to the arranged time intervals between the two daily feedings. Parameters used to assess changes in rumen fermentation were pH, concentrations of total acids and bases, the acid ratios of seven individual acids in the total acids and the concentrations of dissolved Na, K, Ca and Mg in the fluid.

The supplementation caused a significant increase in pH, in the proportions of acetic and isobutyric acids of the total acids, and in the content of dissolved calcium. Significant decreases were observed in the proportion of n-butyric and isovaleric acids of the total acids, and the concentration of dissolved sodium. No or only insignificant changes occurred in the concentrations of ammonia, total volatile fatty acids, the proportions of propionic, n-valeric and n-caproic acids of the total acids and the contents of dissolved potassium and magnesium.

The observed significant decline of the proportion of n-butyric acid with the increased calcium supplementation paralleled by an accelerated decline of the n-butyric acid fraction during the first two hours after feeding can indicate that calcium might be involved in stimulating the rate of absorbing the acids from the rumen.

Title: Efficacy of an Additive for Wilted Haycrop Silage

Leader: J. B. Holter, New Hampshire

The objective was to determine if dry SILAGE-SAVOR (Kemin Industries, Des Moines, IA), added at the rate of .05% at ensiling to wilted grass silage, would reduce silo temperature, reduce storage loss, increase silage intake, or improve nutritive value of the resulting silage.

As a procedure, SILAGE-SAVOR was added at the prescribed rate to wilted haycrop silage (mixed, mostly grass) ensiled in a 4.3 x 13.7 m tower silo. Alternate loads of untreated (control) silage were ensiled in a 4.9 x 9.1 m tower silo. Dry matter was 40 to 50%.

The results were that silo core temperature remained about 5 C lower for treated silage throughout 110 days after ensiling. Storage efficiency (80%) and proportion of nitrogen in acid detergent insoluble fraction were not affected by treatment. Ad libitum intake in bred heifers was 1.7% body weight for both silages. On a dry matter basis, apparent digestibility of crude protein was 40% higher (56 vs. 40%), TDN was 12% higher (61 vs. 54%) and ME was 12% higher (2.26 vs. 2.01 Mcal/kg) in treated than in control silage. Digestibilities of dry matter, energy and other nutrients (except NFE) also were significantly higher (8 to 13%) in the treated silage. Improved digestibility of protein was sufficient to return \$3.00 for each \$1.00 additive cost.

Title: PROJECT NE-24 -- 641, Nutritive Evaluation of Forages:Calcium Metabolism

Leader: J. L. Evans, New Jersey

Two trials with Holstein cows were carried out to investigate the influence exerted by ration Ca and acidity (pH) on milk production; voluntary dry matter intake; Ca, phosphorus and magnesium balance; and carry-over effect(s) of dry period Ca on lactation parameters.

In the trial I dry period, the more acidic versus the less acidic rations averaged higher in total (25 and 14 g) and percent (29 and 14%) retained Ca. Even though more acidic rations elevated endogenous Ca loss in cattle, older cows tended to benefit from more acidic rations at parturition. The age-by-ration acidity interaction in trial II indicated a trend toward the acidic ration reducing the level of serum Ca depression and the inverse elevation in serum magnesium. Another deviation from parathyroid-stimulation-theory occurred in the day 2 postpartum retained Ca data in trial II. Retained Ca was higher (47 versus 12% and 69 versus 4 g) with higher versus lower ration Ca (143 and 19 g). Both Ca groups reversed their absorbed Ca status between 7 days prepartum and 2 days postpartum, benefiting the higher Ca group.

It is this initial and continuing larger amount of available Ca carry-over at parturition that the authors feel benefits milk production. The significant dry period Ca carry-over demonstrated in early lactation in trial I was reconfirmed by trial II data. Milk production followed dry matter or energy intake, and voluntary dry matter intake was increased with higher ration Ca in trials I and II. At lactation week 12 in trial II, the 600 kg body weight cow ingested 18 kg dry matter on HH (high in dry period and high in lactation period) Ca; 15 kg, NRC (1971) Ca in both periods; and 14 kg, LL Ca. The difference in milk production at week 12 was about 7 kg/day between higher and lower intake groups in trial II and similar to trial I data. An increased Ca in the ration tended to reduce the absorption and/or retention of magnesium and phosphorus. However, positive balances for magnesium and phosphorus were maintained.

In trial II, cows were blocked by age. The first-calf cows had the lowest serum magnesium and the highest serum Ca. It may be that the larger exchangeable bone Ca reserve combined with lower ration Ca depressed serum magnesium. Low serum magnesium (average of 2 mg/100 ml and less from parturition to 10 days postpartum) in 12 first-calf cows was associated with reduced to nearly no ration ingestion. This off-feed syndrome was reversed by a magnesium drench. The authors feel that this off-feed syndrome in younger cows was more detrimental than the potential relief from milk fever in older cows with low Ca rations.

The true absorption of Ca at the NRC (1971) level was 44% which agrees well with the NRC value of 45%. However, the absorption of Ca decreased with an increasing intake of Ca. In order to maximize absorbed Ca in the presence of a decreasing absorption rate, a 50% increase over the current NRC (1971) Ca is required.

Title: Prediction of Feed Intake from Laboratory Analyses

Leaders: P. J. Wangness and B. R. Baumgardt, Pennsylvania

More accurate means of estimating feed intake will aid in deciding how much forage or concentrate to include in a complete feed to permit adequate intake for a given productive purpose. Because factors affecting feed intake can be both physical and physiological, any attempts to estimate intake should be consistent with both types of factors. In order to estimate intake from dietary characteristics, one characteristic such as digestibility was found to be inadequate, but consideration must also be given to measures of the physical nature of the diet and to the level of energy demand of the animal. Multiple regression equations were used to identify easily measured diet characteristics which were significantly related to dry matter or digestible energy intake. In growing wether trials, some important characteristics were density, in vitro dry matter digestibility, % neutral detergent fiber (NDF), NDF digestibility and rate of in vitro NDF digestion. These variables and their interactions accounted for >80% of the variation in dry matter intake over a wide range of diets. Similar results were obtained with more limited data from cattle and swine trials.

Title: Infrared for the Nutritional Evaluation of Crops and Miscellaneous Feedstuffs

Leaders: J. S. Shenk, M. R. Hoover, R. R. Hill, Jr., B. R. Baumgardt, and G. W. Fissel, Pennsylvania and U.S. Pasture Research Laboratory

During the past year our infrared spectro-computer system has gone through a second stage of development. The PDP 11/10 CPU has been replaced with a 64K PDP 11/34 and current software converted to the mapped version of RSX-11M system. The encoder with digital display was added to the monochromator to provide accurate control and monitoring of the monochromator. Dual filters were installed to allow expansion of the scanning capabilities to the range 1.0 to 2.6 μm . The current IR data collection procedure is 10 msec. delay, 20A⁰/point, 512 readings/point, 4 points smoothed on either side of point, and scanning from 1.0-2.6 μm . Scan time is approximately 90 sec.

Sample holders were manufactured 50 cm in diameter with 2 g capacity, and a carousel turntable holding 8 samples was installed for manual operation of the sample charger. A vacuum system was added to remove small particles from the sample holders when they are cleaned between sample filling.

The 8 programs used to operate the system have been modified to operate under the mapped system and expanded data collection. Improvements and additional options were made to some programs to expand their capabilities. The new computer system combined with the improvements to the monochromator will provide for greater flexibility and expansion of the technology.

Additional funds were made available from the College of Agriculture to build a small, compact infrared reflectance instrument. This instrument will contain a newly developed miniature monochromator for data collection. A telephone interface will be used to communicate with the PDP 11/34 computer from remote locations.

Forage samples have been received from Illinois, Kentucky, Minnesota and Wisconsin to increase the size of our data bank. One hundred and sixty-four samples containing forage preserved as hay or haylage, corn silage, and high moisture corn were used to develop calibration equations for protein and acid detergent fiber (ADF). The protein equation contained 8 wavelengths with a standard error of calibration (SEC) of 1.00%. The ADF equation contained 14 wavelengths with a SEC of 2.03%.

A total system is in operation. Our preliminary findings suggest that the system is as accurate as the one designed and built by Karl Norris at Beltsville, Maryland. Our capabilities to handle large quantities of data and our computer capacity for program development will provide the necessary flexibility for future expansion into various areas of application.

Title: The Comparative Value of Penngift Crownvetch as a Forage for Ruminants

Leaders: M. L. Risius and T. A. Long, Pennsylvania

Penngift crownvetch and Viking birdsfoot trefoil were harvested twice during the growing season, preserved as hay and silage, and fed to sheep to evaluate the apparent digestibility of dry matter, energy and protein as well as animal intake. Voluntary daily intake (g/day) of birdsfoot trefoil by sheep was higher than that of crownvetch for both harvests and methods of preservation but only of a significant magnitude for first harvest silage. For both harvests and methods of preservation, the apparent dry matter digestibility of birdsfoot trefoil was higher than that of crownvetch. The gross energy levels were nearly the same for both species, methods of preservation, and harvests. However, the digestibility of the gross energy was higher for birdsfoot trefoil than for crownvetch in both harvests. Consequently, the digestible energy of birdsfoot trefoil exceeded that of crownvetch. The percentage digestible crude protein in crownvetch hay was comparable to that in trefoil hay but the digestible crude protein in trefoil silage exceeded that of crownvetch silage at first

harvest. However, the digestible crude protein of either crownvetch hay or silage was higher than that of trefoil silage at second harvest. Preservation of crownvetch as silage resulted in significantly lower digestible crude protein when compared to hay at first harvest, but no difference was observed between methods of preservation in second harvest crownvetch forage.

Title: The Meadow Vole as a Bioassay of the Nutritive Value of Forages and Cereal Grains

Leaders: J. S. Shenk, Pennsylvania, W. A. Kendall and D. L. Gustine, U.S. Pasture Research Laboratory, and R. F. Barnes, USDA, Beltsville, Maryland

A meadow vole colony has been in operation at The Pennsylvania State University for 6 years. The breeding colony consists of 16 breeding harems of 1 male and 2-4 females per cage. Over 2,500 weanlings have been available each year for various experiments. Primary emphasis has been directed toward determination of the weanling's nutritional requirements. Adults have been used to study plant factors associated with the palatability of forages. This information has been used to devise specific bioassay procedures to study the relative nutritional value of a wide range of cultivated crop species.

Weanlings have been used to evaluate the quantity and quality of protein available for growth from cereal grains and soybeans as well as the energy available for growth from temperate and tropical forages. Studies of antiquality constituents with weanlings have led to the identification of a toxic constituent in crownvetch forage and the verification of undesirable constituents in raw soybeans and forages. Studies with adults have assisted in clarifying the effects of forage saponins and alkaloids on the palatability response of adult voles. Each of these studies has provided some type of new and useful information that has implications in either nonruminant or ruminant responses to crop plants.

Title: Development and Application of Laboratory Methods of Evaluating Forage Quality

Leader: W. A. Kendall, U.S. Pasture Research Laboratory

A meadow vole bioassay was used to evaluate effects of plant diseases on the palatability of some forages that were provided by Dr. K. T. Leath of this Laboratory. All samples were dried and ground and, in addition, red clover with powdery mildew was tested with fresh leaves. The

palatability of alfalfa was decreased by infection with *Phoma* or *Stemphylium*. The palatability of red clover infected with powdery mildew and orchardgrass infected with either rust or purple leafspot was not affected.

A study was made of the feasibility of using the meadow vole bioassay for palatability to detect substances that enhance palatability. Synthetic diets that contained various carbohydrates that differed in sweetness and digestibility and sodium saccharin were evaluated. Results indicated that palatability ratings may be affected by the glucose/energy levels of the diet as well as the degree of palatability.

Title: Studies on Allelochemical Properties of Crownvetch and Their Effect on Forage Quality

Leaders: D. L. Gustine, U.S. Pasture Research Laboratory; B. G. Moyer, P. J. Wangsness, J. L. Moniot, M. Shamma, and J. S. Shenk, Pennsylvania; and P. E. Pfeffer, Eastern Regional Research Center, Philadelphia, Pennsylvania

Three new 3-nitropropanoyl-D-glucopyranoses, 2,3,6-tri(3-nitropropanoyl)- α -D-glucopyranose (corollin), 1,2,6-tri(3-nitropropanoyl)- α -glucopyranose (coronillin) and 2,6-di(3-nitropropanoyl)- α -D-glucopyranose (coronarian), were isolated from the aerial parts of crownvetch (*Coronilla varia*). Two other glucose esters of β -nitropropionic acid (BNPA), cibarian (1,6- β diester) and karakin (1,2,6- β triester), were also isolated. Structural assignments were made on the basis of 220 M Hz nuclear magnetic resonance spectra. These compounds and BNPA were shown to be toxic to nonruminant animals, but their lack of toxicity to ruminants had not been explained. Investigations of the metabolism of these compounds by in vitro rumen fluid incubations established that rumen microorganisms detoxify these aliphatic nitro-compounds. When incubated in rumen fluid, the esters, which are the naturally occurring form in crownvetch were degraded to BNPA and presumably glucose within 4 hr, while BNPA was degraded to unknown products within 20 to 24 hr. Studies with a fistulated sheep suggested, but did not prove, a much faster rate of BNPA degradation in vivo (6 hr). BNPA was not degraded in rumen fluid that was centrifuged (microbe-free), establishing that the rumen microbiota are responsible for degradation. When diets containing lyophilized rumen fluid (incubated with BNPA) were fed to weanling meadow voles, no adverse effects were observed, establishing that detoxification of BNPA occurred during incubation. Further, sheep feeding trials with alfalfa and crownvetch (.6% BNPA by analysis) over a 4-week period resulted in equivalent weight gains. On the basis of these findings, we conclude that the aliphatic nitro-compounds in crownvetch are detoxified by rumen microorganisms in vivo; therefore, this forage may be fed safely to ruminant animals.

Title: Mineral Effects on Nutritive Quality of Forages

Leader: R. L. Reid, West Virginia

Trials were continued to determine the effect of mineral availability on the intake and utilization of two perennial grasses with markedly different nutritive characteristics--perennial ryegrass and tall fescue. The grasses were fed as cut herbage at two growth stages in comparative trials with lactating beef cows and growing lambs; with the lambs, herbage was fed at controlled and ad lib. intake. With both cattle and sheep, DMD and intake were higher on ryegrass than on fescue, with greater differences at the immature growth stage. Intake by cows (as g/kg BW^{.75}) was much higher than by lambs. Availability of minerals, particularly Ca and P, differed between grasses and between cattle and sheep.

Further studies were made, in a cooperative project with the USDA Regional Pasture Research Laboratory (G. A. Jung), on the effects of Mg fertilization of forages on intake and DMD. With sheep, intake of DM from first and regrowth cuttings of alfalfa was significantly increased by fertilization with Mg in the sulfate form. Trials are presently being conducted to determine the effects of MgSO₄, and high or medium levels of elemental S, on the intake and utilization of orchardgrass and alfalfa hays in different cuttings by beef cattle and sheep. Analysis of results is incomplete.

Title: PROJECT NE-24--The Nutritive Evaluation of Forages

Principal Leaders and Cooperating Agencies: J. G. Welch, A. M. Smith, Vermont, and R. T. Wetherbee, Regulatory Service, Vermont

Pilot studies measuring rumen weight assention time, dyed particle passage and rumination indicated the following: full (ad lib.) feeding was associated with longer rumen weight assention times and slower rate of passage of dyed particles than limited feeding (1/2 of ad lib.). Four meals/day produced more rapid rumen weight assention times, more even rumination activity and more rapid passage of stained particles than did the same amount of hay in a single meal. In a 4 x 4 Latin square experiment, fistulated steers were fed rations of all hay, all corn silage, alfalfa pellets, or 75% concentrate 25% hay. Rumen weight assention time, rumination time, rumen particle size, rumen dry matter, fecal particle size and voluntary intake were measured. Treatments produced significant differences in all measurements except rumen dry matter, and fecal particle size. Important correlations included: weight assention time vs. rumen particle size ventral, am r=.63**; vs. rumination time r = .63** vs. fecal particle size .08, vs. fecal dry

matter $r = -.32$. Rumen particle size was correlated with rumen dry matter $r = .56^*$, rumination time $r = .81^{**}$, fecal particle size $r = .44$. Rumination time was correlated with fecal particle size $r = .55^*$; dry matter intake was correlated with rumen particle size $r = .46$ and fecal particle size $r = .41$. There was a low correlation between weight assention time and voluntary intake; an assention $r = .06$ and pm assention time $r = .14$ indicating that in this experiment the consistency of the rumen ingesta has little association with voluntary intake.

In a second 4 x 4 Latin square experiment intake of hay was controlled to 40,60,80, or 100% of voluntary intake. Intake was correlated with weight assention time $r = .60^*$, rumen DM $r = .89^{**}$ and rumination time $r = .72^{**}$.

In an experiment with 48 mature dry cows of varying body size fed hay according to $BW_{kg}^{.75}$, rumination time per gm of CWC ingested decreased with increasing body wt. Fecal particle size was unchanged with increased body wt.

SECTION IX

SILAGE RESEARCH

Title: Effect of Corn Silage:Grass Silage Ratio in Complete Feeds with 35% Concentrate During Lactation and with and without Concentrate During the Dry Period on Health, Reproduction, and Production of Dairy Cattle

Leaders: J. E. Keys and R. E. Pearson, USDA, Beltsville, Maryland

Approximately 15 Holstein cows/year are currently being assigned to one of two corn silage:grass-legume silage (DM basis) ratios (75:25 and 50:50) complete mixed feeds at the end of their first lactation. Half of the cows on each forage ratio treatment are fed concentrate at the rate of 35% of the ration dry matter and half are fed only the forage portion during the dry period. All cows are fed 35% concentrate during lactation. Cows will stay on trial for two complete dry periods and two complete lactation periods.

Insufficient numbers of cows have completed their first and second lactation on this trial to permit conclusions at this point in time.

Title: Formaldehyde and Other Additives for Ensiling Forages

Leaders: D. R. Waldo and H. K. Goering, USDA, Beltsville, Maryland

First growth orchardgrass was cut in the bloom stage for wilted silage (w), wilted silage made with .15% paraformaldehyde (f) and ground hay (h). These forages were fed to beef steers without (o) or with corn meal (c) as 10% of dry matter. Average daily gain (kg) and dry matter intake as a percent of body weight were (wo) .49, 2.09; (wc) .77, 2.78; (fo) .26, 2.04; (fc) .79, 2.82; (ho) .94, 3.66 and (hc) .80, 3.93. The experiment was repeated with fall growth orchardgrass without hay. Average daily gain and dry matter intake were (wo) .30, 2.41; (wc) .41, 2.80; (fo) .31, 2.06 and (vc) .37, 2.22. Fall growth alfalfa was used in another experiment where the silage was fed without (o) or with 180 mg monensin (m) per steer per day. Gain and intake for steers fed silages were (wo), .46, 2.55; (wm) .40, 2.31; (fo) .52, 2.59 and (fm) .41, 2.39.

Prebloom first cutting of alfalfa was ensiled in duplicate 1.22 X 2.44 m silos directly (d) either without (o) or with .07% paraformaldehyde (p) or after wilting (w) either without (o) or with .1% paraformaldehyde (p). Hot-water insoluble nitrogen in the alfalfa before and after ensiling was (do) 60.2, 32.2; (dp) 59.0, 40.2; (wo) 53.9, 29.7; and (wf) 52.1, 33.8% of the nitrogen. Daily dry matter intake was 62, 66, 84, and 88 g/W^{.75} kg.

Title: Influence of Heat and Other Processing Variables on the Utilization of Forage Nitrogen

Leaders: H. K. Goering and D. R. Waldo, USDA, Beltsville, Maryland

Control (C) and formaldehyde-treated (F) silages were fed without supplement (O), with formaldehyde-treated protein (P) or isocaloric amounts of corn meal (M). Daily nitrogen balances were: CO 13; CP 26; CM, 11; FO, 21; FP, 39; and FM, 24/g. Daily gains were: CO, 47; CP, 69; CM, .56; FO, .66, FP, .69 and FM, .62 kg. The degradation of protein in untreated silage reduces nitrogen and growth; these are corrected by feeding either silage with protected protein or protected supplemental protein but not isocaloric supplements of energy.

The true protein nitrogen as a percentage of total nitrogen and the standard deviations as measured by insolubility in autoclaved rumen fluid were oats, 28 \pm 10; wheat midds, 45 \pm 5; malt sprouts, 50 \pm 4; gluten feed, 52 \pm 13; wheat bran, 54 \pm 10; soybean meal, 58 \pm 9; cottonseed meal, 68 \pm 8; barley, 69 \pm 10; alfalfa meal, 77 \pm 7; hominy, 79 \pm 9; corn, 79 \pm 8; distillers dried grains, 82 \pm 4; brewers dried grains, 88 \pm 4; beet pulp 88 \pm 6; and gluten meal 93 \pm 2.

Preharvest wilting of forage by spraying with formic acid increased initial dry matter from 15.5% to 19.5% later that same day, 20.2% one day later, 23.6% four days later, and 22.2% seven days later but after .23 inch rainfall on the sixth day.

Title: Grasses and Legumes for New Jersey

Leader: Milton A. Sprague, New Jersey

First-year yields of 10 promising alfalfa varieties identified Saranac AR, ARC, and WL-31 as superior to others tested. Yields totaled 7.42, 6.91, and 6.81 tons per acre, respectively, compared with about 5.5 tons for others tested. Anthracnose resistance identifies the higher yielding varieties from others and this disease has become a major problem in New Jersey.

Title: Corn Silage as the Only Forage for Lactating Cows

Leader: R. F. Davis, Maryland

Comparisons of lactation performance and animal health are being made on rations with corn silage as the only forage and corn silage during lactation and hay during the dry period. One half of the group is fed a corn-based concentrate, the other half a barley-based concentrate. Forty cows have been started on the experiment.

The study will involve three lactations and is in its last year. Several animals have left the experiment before completing the three lactations.

Differences among treatments for numbers of cows leaving the experiment are not apparent at this time.

Average times on the study for each treatment are as follows: all silage-barley concentrate, 120 weeks; silage and hay-barley concentrate, 110 weeks; all silage-corn concentrate, 94 weeks; silage and hay-corn concentrate, 116 weeks.

SECTION X

ENVIRONMENTAL RESEARCH

Title: Potential Groundwater Pollution from Sewage Sludge Application on Agricultural Land (Connecticut Institute of Water Resources Project)

Leader: R. W. Wengel, Connecticut

Measurement of corn silage yields and uptake of heavy metals by the corn are included in this first year of a planned 5-year project. Applications of 0, 6.2, 13.9, 27.8, 41.7, and 55.6 tons (DM)/acre of sewage sludge were made on corn land and plowed under in May 1976. Corn silage yields were 14.4, 25.5, 28.5, 36.4, 37.9, and 36.2 tons (30% DM)/acre, respectively. Heavy metal content of the sludge was relatively low for Ni (65 ppm), Pb (220 ppm), Cd (5 ppm), Cu (175 ppm), and Zn (582 ppm). Metal uptake by the corn was low. Only Zn was taken up in proportion to rates of sludge application, with a maximum of 71 ppm in whole plant tissue.

Title: Effects of Sewage Sludge on Soils and Yield of Corn and Soybeans

Leaders: A. M. Decker and R. L. Chaney, Maryland

Corn and soybeans were grown for the fifth season on field plots that had received 0, 25, 50 and 100 dry tons of digested sewage sludge in the spring of 1972. The pH was well below 6.5 so 1 ton of lime was applied before plowing and 1 ton was disked into the soil at final seedbed preparation. As in past years, 80 lb each of P₂O₅ and K₂O were applied to all fertilized plots; in addition, all fertilized corn plots received 160 lb N/acre.

Corn grain yields ranged from 1.4 bu/acre at zero fertilizer and sludge to 116 bu/acre with 100 tons of sludge plus fertilizer. Fertilizer significantly increased grain yields at 0 and 25-ton sludge rates but not at the 50- or 100-ton sludge rates. Silage yields followed the same pattern but differences were smaller. Soybean yields were 24, 27, 33 and 34 bu/acre for the 0, 25, 50, and 100-ton sludge rates, respectively. There was no fertilizer response at any of the sludge rates on soybeans.

Title: Effects of Sewage Sludge and Soil Temperature on Plant Response and Heavy Metal Uptake

Leaders: C. C. Sheaffer, A. M. Decker, and R. L. Chaney, Maryland

Field corn and radishes were planted in the spring of 1976 into field plots containing soil which had been amended with sewage sludge at rates of 0, 56, and 112 metric tons per hectare. Plots were subjected to soil temperatures of ambient (22 C), 16, 27 and 35 C. Corn samples were taken at the 5-6, 8-9, and 11-12 leaf stages, ear leaf at pollination, and maturity. Grain and stover yields were determined. All plant material was analyzed for Zn, Cu, Ni, Cd, and Pb.

Soil temperature and sludge application had a significant effect on grain and stover yields. Growth of corn at 27 and 35 C produced significantly higher grain yields than at 16 C and ambient. Stover yields increased significantly as soil temperature increased from 16 to 35 C. Both grain and stover yields increased significantly with sludge rates.

Heavy metal analysis of all plant material is incomplete and will only be reported for stover and grain. Zinc levels in grain and stover were significantly higher in sludge amended plots. Soil temperature had no significant effect on the zinc content of grain or stover from sludge amended plots. Copper, nickel, and lead content of grain and stover was unaffected by temperature or sludge application. Cadmium levels in the grain were not significantly affected by the treatments; however, levels in stover grown on plots amended with 56 mT/ha sewage sludge and subjected to a soil temperature of 22 C had significantly higher levels of cadmium than stover from other treatments.

Title: Sewage Sludge Utilization in the New Jersey Pine Barrens

Leaders: R. W. Duell, D. K. Markus, and D. W. Platt, New Jersey

The effect of supplemental K on grasses treated with surface applied sewage sludge for 3 years was investigated. Plant tissue analyses of previous seasons indicated barely adequate K contents. In the fall of 1975 applications of 200 kg K/ha from KCl were superimposed on portions of plots of Midland bermudagrass and a cool-season grass mixture that received several surface applications of sewage sludge per year for 3 consecutive years to total 0, 22.4, 44.8, and 89.6 tons/ha/year.

Widespread winterkilling of Midland bermudagrass on sludge-treated plots precluded collection of meaningful yield data. Survival was better on Downer loamy sand which had a better native K supply, than on Lakewood sand or Woodmansie sand. Survival was better where K was supplemented than where it was not. Survival was better in plots receiving low sludge rates or no sludge, and where the Midland bermudagrass had not been defoliated regularly. No winterkill of the cool-season grass mixture on Lakewood sand could be detected. Orchardgrass and tall fescue had been depleted from all plots

and Kentucky bluegrass and increased in sludge-treated plots during the first 3 years of the trials. The weedy plots that received no sludge showed yield increases of about 15% due to supplemental K. Kentucky bluegrass-dominated plots receiving supplemental K showed increased yields of more than 100%. Drought stress symptoms were evident in K deficient plots. Huge fairy rings caused by Marasmius spp. damaged plots of Kentucky bluegrass receiving heavy sludge loadings. Leafspot (Helminthosporium spp.) appeared on sludge-treated Midland bermudagrass.

Low K and high N supplied from sewage sludge, particularly on low K soils, where defoliation may have depleted carbohydrate reserves, appear to have been additive in contributing to winterkilling of Midland bermudagrass, but not Kentucky bluegrass.

Title: Disposal and Utilization of Dairy and Poultry Manure by Land Application

Leaders: H. D. Bartlett and L. F. Marriott, Pennsylvania

Dairy manure slurry was injected under orchardgrass sod in fall or in spring at annual rates of 300, 400 and 500 lb N/acre for the crop years 1974 and 1975, with a check treatment of urea at 100 lb N/acre. No treatments were applied for 1976, but the plots were harvested to determine the residual effect of the manure. Nitrogen removal in the forage was about 50% of 1975 removal, although yields ranged from 60 to 85% of respective yields in 1975. Manure N efficiency was 30 to 40% over the 3-year period. Soil water samples from depths of 2, 3 and 4 ft obtained from suction lysimeters where manure had been applied contained an average of 16 mg/l of nitrate N in February, but this declined to 6 mg/l or less by June. The water and yield data support the conclusion that the lowest rate used (300 lb N/acre) applied in early spring supplied adequate N for the grass and provided the least pollution potential.

Injected manure posed some problems in proper placement of suction lysimeters for water sampling, since nitrate N concentration varied widely depending on where the lysimeter was placed in relation to the center line of injection. Another experiment was established on bluegrass, with dairy manure slurry evenly distributed over the small plots by hand to avoid the effect of point application. Rates applied were 260 and 520 lb N/acre in fall 1975, on sod or 4 in. under, and on the surface or below the surface where the sod had been removed (bare).

While nitrate N levels increased substantially in the water at the 1 ft depth in early spring, there was a decline to about 10 mg/l or less by June. A slight increase at the 2-ft depth also disappeared and there was no effect at the 4-ft depth. Nitrate levels were considerably higher where no sod was present. Spring applications of 450 and 900 lb N/acre, with treatments as in the fall, produced results at the lower rate similar to those described. The higher spring rate resulted in higher nitrate N at 2 and 4 ft. Yields of bluegrass forage ranged from 2 1/4 to 3 1/2 tons

dry matter/acre. About 1/3 of the manure N was removed in the forage. This 1 year of data has given no reason to change the conclusion indicated earlier.

Manure injected at 150 and 380 lb N/acre before planting no-till corn following alfalfa increased yield from 157 bu/acre (check) to 194 bu/acre at the higher manure rate. Early growth of the corn plants was enhanced where the corn was planted in the row where the manure was injected. (The manure had been applied about 3 weeks before corn planting.)

No-till corn was grown a third year on plots which had received dairy manure injections to supply 700 to 3500 lb N/acre/year during 1969-1971. Yields ranged from 123 to 170 bu/acre of 15.5% moisture grain, compared to the check yield of 75 bu/acre.

Results of a preliminary soil sampling to 4 ft, the first since 1972, indicated that some potassium had migrated an additional 6 in. on the more heavily manured plots, with the greatest depth affected being 30-36 in. Some magnesium increases were found at the 18- to 24-in. depth while calcium had not moved from the 0- to 6-in. depth. Nitrogen was primarily in the 0- to 6-in. layer (55 to 70%), some in the 6- to 12-in. layer (25 to 35%) and at the two highest manure rates, 20% at the 12- to 18-in. depth. Nitrogen below the depths indicated showed no increase from the manure application, and was not included in the percentages shown.

Title: Effect of Sprinkler Irrigation with Municipal Sewage Wastewater and Cutting Management on Nutritive Value of Reed Canarygrass Clones Established in 1974

Leaders: K. E. Zeiders and R. T. Sherwood, U.S. Pasture Research Laboratory

In 1975, for plants under 2-cut management, the nutritive value of nonirrigated forage was higher in terms of the mean percentage in vitro dry matter disappearance (IVDMD) and crude protein (CP) than forage irrigated with sewage wastewater. The IVDMD and CP percentages of both irrigated and nonirrigated forage were higher on October 3 (3rd cut) than on June 3 (1st cut). On July 31 (2nd cut), the percentage IVDMD of leaves from irrigated plots was about 5% greater than nonirrigated plots, while CP percentages were about the same (23%). For plants under 3-cut management, the values for IVDMD and CP on October 3 were greater than on July 31. The IVDMD and CP values of leaves were substantially higher, regardless of irrigation or cutting treatment, than values of forage consisting of stems and leaves. In 1976, the 2-cut irrigated plants had greater mean values for IVDMD and CP than 2-cut nonirrigated plants on October 12, probably because additional N was added to irrigated plots in August. However, corresponding plants under 3-cut were substantially greater in IVDMD and CP than plants under 2-cut management. Irrigation had little effect on the IVDMD and CP values of 3-cut plants on August 10 and on October 12. In 1976, 3-cut irrigated plants had greater IVDMD and CP values than 2-cut irrigated plants.

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RECIPIENTS OF GRADUATE DEGREES - 1976M. S. Degree

<u>Name/Institution/Advisor</u>	<u>Thesis Title</u>
Catron, P. E. Rutgers University Ralph E. Engel	Methods of Screening Bentgrass for 2,4-D Tolerance.
Edelbert, Ralph Rutgers University Robert W. Duell	Effect of Soil pH on the Emergence and Growth of Grasses and Legumes.
Kalu, Bernard Awa Cornell University	Age and Time of Year Effects on Alfalfa (<u>Medicago sativa</u> L.) Quality and Morphological Development.
Mainer, Angel The Pennsylvania State University Kenneth T. Leath	Effect of <u>Phoma</u> and <u>Stagonospora</u> Diseases on the Quality of Alfalfa and Orchardgrass Leaf Tissue, Respectively.
McCormick, C. C. West Virginia University R. L. Reid	The Nutritive Value and Mineral Availability of Pasture Herbage for Cattle and Sheep.
Mustain, B. C. Rutgers University Milton A. Sprague	The Ranges of Variability in Parameters Involved in Growth and Differentiation of <u>In Vitro</u> Plant Material.
Nestor, Roger L. West Virginia University John A. Balasko	Contribution of Several Warm- Season Grasses to West Virginia Grasslands.
Pandya, A. S. The Pennsylvania State University J. B. Washko	Relationships Between Planting Period, Yield, Carbohydrate Reserves and Regrowth of Alfalfa During the Establishment Year.
Russo, Sandra Lee The Pennsylvania State University John S. Shenk	Assessment of Laboratory Techniques as Estimators of Quality of Tropical and Temperate Grass Species.

RECIPIENTS OF GRADUATE DEGREES - 1976M. S. DegreeName/Institution/AdvisorThesis Title

Sumberg, J. E.
Cornell University (1977)

Effects of Managements and
Varieties on Yield and Quality
of Alfalfa Forage.

Ph.D. Degree

Bruetsch, Theordore F.
University of New Hampshire
G. O. Estes

Physiological Factors
Affecting the Differential
Uptake and Accumulation of
P by Long and Short Season
Genotypes of Maize.

Rao, V. P. R.
West Virginia University
R. L. Reid

Effects of Silica on the
Nutritional Quality of Forages.

