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Managing Forages for Animal Production - Blaser

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Managing Forages for Animal Production

1949-1969 History and Research Findings,
Virginia Forage Research Station,
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CONTENTS

IT IS GIVEN TO FEW OF US to influence the lives of thousands of our fellow men—for good or for bad.

But through a combination of a wise selection of parents and personal sagacity, such influence has been given to Paul Mellon. That he has used these gifts wisely, we are here today to attest.

It was largely through his efforts, with the help of a small group of Middleburg citizens, that the Virginia Forage Research Station became a reality 20 years ago today.

Results of research from this Station have become known not only in our State and Nation, but worldwide. The application of these results has meant, and will continue to mean, progress in agriculture in many nations.

Gratefully, this publication is dedicated to Paul Mellon, in recognition of his financial support, his personal interest, and his faith in those in whose trust these facilities have been placed.

—The Staff, Virginia Forage Research Station, and the Research Division, Virginia Polytechnic Institute, Blacksburg, Va.; July 11, 1969.

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SECTION I

The Station: Its Contributions, Its Origin, Its Structure

By harvesting his best spring pasture growth—and putting his cattle on an all-year feeding program of hay, silage and grazing—a farmer can step up his output of meat or milk dramatically.

By using the entire corn plant as cattle feed, including the green parts long considered roughage, a farmer can produce just as good beef or just as much milk as if he fed his animals an expensive high-grain ration.

By restricting feed to cows while giving his calves as much as they can eat, a farmer can sharply reduce his cost of raising calves.

These are three discoveries of the Virginia Forage Research Station, Middleburg, Va. Prosaic-sounding to the casual reader, perhaps, these findings and the many like them detailed in Part III are of major import in agriculture.

They are helping farmers expand production of meat and dairy products while holding down costs. They are helping U.S. families to purchase the meat and milk they want while keeping a checkrein on their budgets. They are helping some families around the world consume meat or milk products regularly for the first time in their lives.

The discoveries of the Virginia Forage Research Station are not overnight revelations. They are the result of patient, carefully laid-out work in an institution specifically created to find better ways of producing meat and milk.

The story began the summer after the end of World War II.

In that summer, 1946, a few public-spirited citizens of Northern Virginia met with officials of Virginia Polytechnic Institute. The meeting was about the need for a comprehensive research program on pastures and forage crops.

It was unanimously agreed that a comprehensive research program on pastures and forage crops was needed in Northern Virginia to obtain information that would aid in further developing forages and livestock production. The group from Northern Virginia expressed a desire to assist in the development of a good pasture and forage crops research program for that section of the State.

At subsequent meetings in the office of the county agent at Warrenton, Virginia, the idea was further explored and general plans for capital outlay, personnel, and other requirements were discussed and agreed upon in principle. It was agreed that when funds became available, the Virginia Agricultural Experiment Station (now part of the V.P.I. Research Division) would initiate and maintain to the best of its ability a program of pasture and forage crops research in northern Virginia which would be equal or superior to similar work elsewhere in the United States. It was realized that such a program would require adequate financial aid and suitable land.

Almost entirely through the efforts of this group of citizens in Northern Virginia, the Virginia General Assembly appropriated funds for pasture research. These funds, however, were insufficient to obtain land, cattle, physical facilities, and personnel. For this reason, Mr. Paul Mellon of Upperville, Virginia, made an original gift of $125,000 to be used for physical facilities, personnel and operations to supplement funds until the State appropriations could be increased. However, the capital outlay funds needed for establishing beef and dairy cattle research facilities were more than anticipated. In addition, it became necessary to provide housing to obtain professionally qualified personnel and technicians to conduct the research. Because of inadequate State appropriations for the physical facilities needed, additional funds were provided by Mr. Mellon and the Old Dominion Foundation.

Land for the Virginia Forage Research Station to conduct research with pastures and forage crops was acquired on July 15, 1949. At a gathering of over 400 people at the Middleburg Community Center, Mr. Mellon announced his donation of two adjoining farms with their facilities to the Educational Foundation of the Virginia Polytechnic Institute and the Commonwealth of Virginia.

Mr. Mellon's national radio address at the Middleburg Community Center meeting 20 years ago puts the founding of the Station in clear perspective today:

> In the summer of 1946 I was invited to join a committee of Northern Virginia landowners who had become interested in certain ideas for the improvement of pasture land and forage crops in this portion of the State. My own farm, where I live permanently, is near Upperville (about 10 miles from here), and the main produce of that farm is cattle: steers which we feed, pasture, and sell. It was apparent to the Committee that, regardless of the extremely high quality of the personnel in our local Extension Service, and the progressive nature of the information which they distributed, true experimental work in pastures and cattle nutrition had been consistently neglected not only in Virginia, but in the Nation as a whole. The opportunity seemed ripe for constructive service to agriculture in general, and to the cattle and dairy people of this State in particular, and we determined to see what could be done.
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> Shortly thereafter, a subcommittee consisting of Mr. Howell Jackson, Mr. Robert McConnell and myself called on Senator Harry F. Byrd for advice on procedure and plans. Senator Byrd, most wisely and most kindly, suggested that we open negotiations with Dr. John Hutcheson, then President of V.P.I., indicating that the Institute was the natural and most efficient vehicle through which our plan could be carried out. He gave us much encouragement and his official blessing.
>
> Mr. Jackson, Mr. McConnell, Mr. Roger Lamdin and myself met Dr. Hutcheson and Dr. H. N. Young, Director of the Virginia Agricultural Experiment Station, in Blacksburg and outlined our ideas. We received their wholehearted cooperation and support, and it was agreed that an effort would be made to raise a substantial and continuing appropriation in the Legislature for such an experimental project, to be located somewhere in Northern Virginia, and a first-class research scientist would be found to head it. At that time, the Legislature had already met and it was too late to secure an appropriation for the next year, 1947. Because V.P.I. had long been interested in such a program itself, however, and because our Committee was eager to help with time, effort, and money, a great deal of interest was created, and the first real appropriation was voted, to be expended in 1948. The appropriation for 1948 and for 1949 was $25,000 each year.
>
> During this time, my own interest in pasture improvement in particular, and in farming in general, was mounting. Also, pasture improvement and the consequent increased economic status of the cattle industry appeared to me more and more to be an important link in soil conservation, in the growing

realization throughout the nation that our soil must be rehabilitated and conserved. More and better pasture means to me a better balanced and an improved general agriculture. It means the checking of erosion and leaching, the rebuilding of work-out soil, the replacement in the soil of organic matter toward its rebirth. In addition, although not a native of Virginia, during almost 15 years of residence here, I had come to love this State and to wish to do something for it, and it occurred to me that anything I could do to improve Virginia's soil and to further the economic wellbeing of a large portion of its citizens would be fitting and most gratifying.

To carry this idea a little farther: I felt that anything I could do, directly or indirectly, to increase even *one* farmer's production would in the long run be a boon to his immediate community. To help the community is to help the County. To help the County is to help the Commonwealth. To help the Commonwealth, however infinitesimally, is to help the Nation.

With these ideas in mind, and with the kind cooperation of Dr. Hutcheson and Dr. Young and the advice and encouragement of Mr. Jackson, I found that I could be of real assistance to the proposed project by making a substantial grant which would assure the immediate and solid establishment of such an Experiment Station, and provide for the employment of an absolutely top man to run it. I was assured by V.P.I. that in addition to the present and proposed State appropriations, private funds of $125,000 would see such a program firmly established and well launched by the first five years of its existence. From then on it is confidently expected that future State appropriations will adequately maintain it. I therefore made that grant to V.P.I.

In the meantime, this Community Center had been established in great part through the generosity and the untiring efforts of Mr. and Mrs. Howell Jackson. It is a model of its kind for every other community in the country. It therefore occurred to me that Middleburg would be a most fitting place for the Experiment Station, and that through cooperation with the Community Center, the use of its facilities for lectures, farm exhibits, farm-club meetings, etc., a great opportunity was available for the dissemination of, and the discussion of, information originating in the Experiment Station.

I had for many years owned a farm near Middleburg. (It is in reality two farms combined, Edgewood and Green Hill, formerly owned by J. Walter Cochrane and Albert Fletcher, respectively.) It is comprised of about 420 acres, and is situated about two miles due south of Middleburg on Route 15. It has been very ably managed by Mr. Robert Fletcher, of Upperville, as I think you will agree when you see it this afternoon.

After a thorough survey of this farm by representatives of V.P.I. I was informed that it was eminently suitable for the purposes of the Experiment Station. I am therefore very pleased indeed to give this farm with all of its equipment, to V.P.I. for use as an Experiment Station for Grass and Forage Corps Research.

In addition to my profound belief in the vital necessity of conservation of the land, and my conviction that the cattle and dairy farmers of Virginia deserve the best that can be given them as a result of science and research, I have an even deeper and more personal urge to further this work. Many of my forbears were farmers. My great-great-grandfather was a farmer when he migrated from Ireland early in the last century. My great-grandfather and my grandfather as a boy followed him shortly after. My great-grandfather cleared with his own hands the land in Pennsylvania that he first settled on, and with his own hands he built his own house. His son, my grandfather, was brought up behind the plow, and it was behind the plow that he (to quote his own words):

"perfected myself in Murray's Latin Grammar, committing to memory the entire seventy-six rules of syntax so that I could repeat them beginning to end without once referring to the book. I accomplished this by repeating the rules when following the plow; keeping the book on the crown of my hat, I resorted to it whilst the team was turning at the end of the furrow, until finally I mastered the whole so perfectly that I could dispense with the book altogether." He also says that "whilst thus engaged in plowing I read the most of Shakespeare's plays."

When my grandfather was 17 (this was in 1830) his thirst for education had become such that he gave up farming in a rather violent manner. His father wished him to remain on the land, and offered to give him a farm of his own which he could purchase for him nearby. He believed (also to quote my grandfather's autobiography):

"that for me to abandon the honest and noble pursuit of an independent farmer, and become a doctor or teacher or miserably dependent preacher: or what was in his eyes worst of all, to enter the tricky, dishonest profession of the law, was a proposition which seemed to him too preposterous to contemplate."

Nonetheless, on the morning of the day that his father had gone into the town of Greensburg to arrange the purchase of this new farm, he suddenly stopped the immediate chore he was engaged in, splitting rails, and he ran the whole ten miles into the town, arriving there at the last moment, to prevent the purchase. From that day on he was through with farming, worked his way through an education in Pittsburgh, studied law, was called to the Bar, and eventually became a Judge of the Circuit Court. In short, he entered the "tricky, dishonest profession of the law." Later, he became a Banker and founded his own bank in Pittsburgh—and in recent years we have heard some pretty hard things said about that profession too!

I do not claim to be a dirt farmer, or a knowledgeable cattle man, or a soil scientist: but the soil is in my blood, and I feel a deep debt of gratitude to the soil of America. When I moved to Virginia and became interested in farming I felt that, symbolically at least, I had run back that ten miles from Greensburg to the farm. By the same token, I look on these two gifts to V.P.I. as a partial repayment of what I owe personally to the soil of my native land, and to the Commonwealth of Virginia, my adopted State.

In making this gift to V.P.I., I would like to add my own thanks and express my heartfelt appreciation, to several men of great good will who are equally responsible in many ways for bringing this project into being. To Senator Byrd, who gave us much-needed advice and tremendous encouragement. To Howell Jackson, who organized the Landowners Committee, fired them and myself with enthusiasm for the plan, and helped us continuously to bring it to fruition. To Dr. John R. Hutcheson of V.P.I. and Dr. Young of the Virginia Agricultural Experiment Station who worked out all the details of the project with the utmost friendliness and cooperation. To Dr. R. E. Blaser, Professor of Agronomy at Cornell University, who gave up his important post at Cornell to take charge of the project in the belief that the most important grass and forage research in the country can and should be done right here in Virginia.

There is one other name which I have not mentioned, but it is a very important one. It is a name that most of you know, the name of a kind man, an able administrator, a man wholly devoted to his soil, his fellow-farmers, and his State: the late Mr. Walter B. Nourse, County Agent of Fauquier County. I did not know Mr. Nourse for very long, but everything that I knew about him in the years I did know him, I liked. I speak with great reverence of his ability, his great interest in this project, and his wholehearted support of it. I know that we all miss him, and felt his absence from this inauguration ceremony with great regret. Although I understand that it is not within the policy of V.P.I. to attach individual names to research stations as memorials, I am sure that you will all agree with me that we can, most appropriately, dedicate the results, both tangible and intangible, that emerge from this project, to the spirit and to the memory of Walter Nourse.

The Virginia Forage Research Station is unique in its organization in that the interplaying factors that influence the soil-plant-animal ecosystem are investigated. For example, grazing experiments are arranged to study the many pasture factors (plant species, mixtures, grazing method, and varieties) on animal production; while at the same time, the effects of cattle on pasture plants and soils may also be investigated. The nutritional and management factors may differ with animals; thus both beef and dairy cattle are used in experiments. In simpler experiments, cattle are used as grazing tools to learn more about the harmful or desirable influence animals have on plants and soils.

Primary purposes of the station are to improve the conversion of pastures, hays, and silages to meat and milk production. During the winter months, forages are studied in separate experiments for producing meat and milk, raising beef and dairy calves and feeding cattle at low costs. Short term trials are also conducted to measure intake and determine digestibility of forages. Switch-back feeding trials are conducted to compare palatability (daily consumption).

Forage variables evaluated with cattle include stage of maturity when cut, moisture content of silages, kind of annual and perennial crops, and use of additives or preservatives in making silage.

Facilities provided for pasture and forages research are pasture areas with watering facilities for many small pasture areas; at one time there were almost 300 enclosures for grazing. The beef cattle center, with a pole barn for hay storage and three silos, is conveniently arranged with nine feeding lots on each side of the barn and facilities for weighing the cattle. Adjacent outside lots are used to investigate the efficiency of raising beef cattle by controlling the rations of cows and calves independently.

The dairy center is provided with a small milking barn for individual cow feeding of concentrate rations and a pipe line milker, a bulk storage tank, a pole barn for hay storage, four silos, and a large open housing shed that has eight lots for pen feeding cows in groups of four. Individual stall housing is used. An additional calf barn is used for calf raising experiments.

A metabolism barn has ten tower silos (8 x 20 ft.) and 10 to 20 pens to study intake and gains of early-weaned calves and yearlings. A special room with 12 elevated metabolism stalls is used to meaure the digestibility of forages. This is done by weighing and chemically analyzing the feed consumed and the subsequent excreta. Digestibilities of forages fed at the beef and dairy centers are obtained with these facilities.

All forages used in feeding rations and the feces from digestibility experiments are analyzed at Virginia Polytechnic Institute by the Department of Biochemistry and Nutrition. Soil, pasture and forages are analyzed for minerals by the Agronomy Department, and research data are analyzed by the Department of Statistics.

The economic success of a livestock farm depends on production costs as compared with prices received for the animal products. Because feed makes up about 50% of milk production and 70% of meat production costs, efforts are underway to improve the efficiency of forage production. Improving the yields of dry matter and the digestibility without adding to the costs of raising pastures and forages will make livestock production more efficient. Field plot experiments in adaptive research are designed to improve production efficiency by finding the best plants, lime, and fertilizer practices and grazing or cutting management for annual and perennial plants. Perennials are evaluated alone and in mixtures for yields and quality, longevity of stands, weed encroachment, pest problems, and grass-legume balance in the mixtures. The effect of some microclimatic factors on growth are measured. The laboratory is used for drying and processing samples and compiling the data. Any promising plant cultural factor can then be evaluated with animals.

Who does the work? Professional staff members with creative immaginations who willingly cooperate in a "team" attack on research problems were sought. The broad and difficult problems in pasture and forage evaluation are thoroughly discussed by individuals with various talents in planning new experiments. Fortunately the Station is a branch of the Research Division of V.P.I. This is beneficial to V.P.I. and to the research program at Middleburg.

The research staff, with R. E. Blaser as overall program leader, is as follows:

Middleburg

H. T. Bryant—forage management and soils

R. C. Hammes, Jr.—animal science in beef cattle production

R. L. Boman—dairy science

Blacksburg

J. P. Fontenot—animal nutrition and biochemistry

C. E. Polan—dairy cattle nutrition

C. Y. Kramer—consulting statistician

R. E. Blaser—ecology of soil-plant-animal interplay.

Research as to *why* (principles) as well as *how* or *what* to do is the backbone of education and advancement of knowledge. The practical research data and principles have been used widely in extension education. The excellent facilities of the Middleburg Community Center are used for annual forage conferences to introduce farmers and agricultural professionals to the newest information. Many farmers visit the research station for information and discussions. The teaching of graduate and undergraduate students in management and utilization of pastures and forages at V.P.I. strongly depends on research data from the Station.

The Station research pursuits have become nationally and internationally significant. Many of the research results in publications have been quoted and referenced in the United States and abroad. Thus, the Station has had professional visitors from various states and from all areas of the world. Staff members associated with the pasture forage research in Virginia are recognized internationally. They have been invited to give papers at professional meetings in the United States and at international science congresses. Likewise, they have been recipients of awards and honors for scientific achievements and services. Some staff members have served abroad as consultants to assist with analyzing and improving training and research programs to aid in food production in developing countries.

Graduate students from various states and from overseas are being trained and educated in the production and utilization of pastures and forage crops and in animal nutrition.

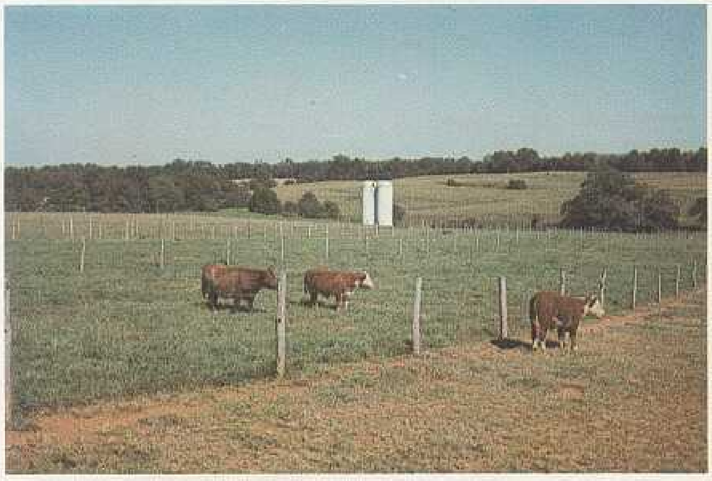
The original name, Northern Virginia Pasture Research Station, was changed to the present name to more clearly describe the research program at the recommendation of Dr. T. Marshall Hahn, President, Virginia Polytechnic Institute, to the Board of Visitors in 1965.

STILL PRODUCTIVE: Alfalfa-orchardgrass mixtures used for silage, hay and grazing in a 12-month forage plan remain productive after six years.

LONGER CHOPPING SEASON results from use of both early (left) and late (right) corn hybrids for chopping as silage when the grain is nearly ripe.

ALFALFA EXPERIMENT in front of Station office building helps in study of maximum dry matter output involving varieties and cutting management.

CHOPPING CORN SILAGE with some greenness makes ideal 40% dry matter silage that animals eat eagerly. It serves as a concentrate.



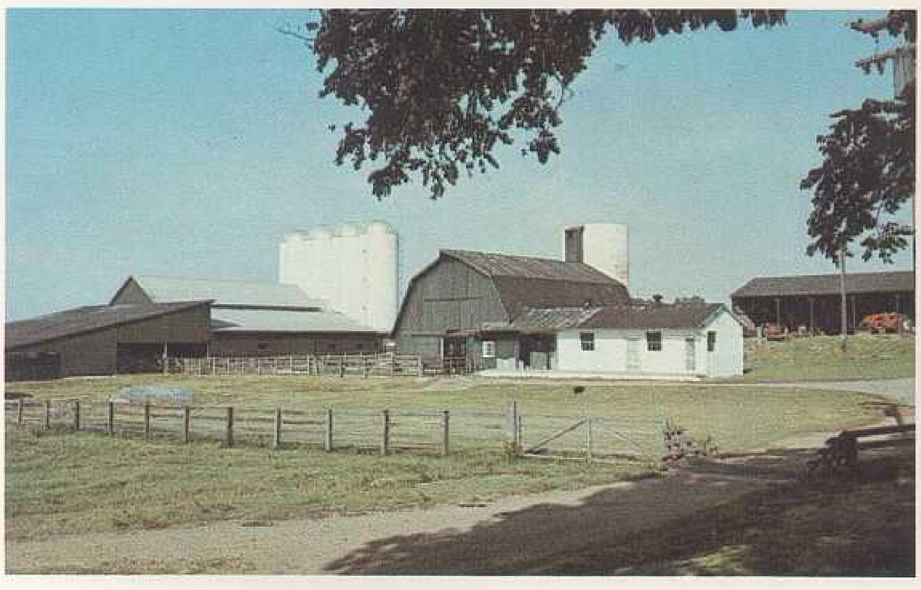
VERY HEAVY STOCKING killed plants in foreground, causing a thin sod. There was more selective grazing and better nutrition with lighter stocking.

NOT QUITE READY: Corn silage in this late milk stage is not yet ready for harvesting as silage, because of excessive water and inferior fermentation.

ADAPTATION RESEARCH: Perennial grasses and legumes, and summer annual crops such as corn and sudan grass, are evaluated for yields and quality.

DOUBLE CROPPING: Small grains harvested for silage in early spring are immediately followed with corn or a sorghum-sudan hybrid. (foreground)

MIXTURES IN FIVE FIELDS were used for grazing, silage and hay in experiments with a 12-month forage program vs. continuous grazing.



SECTION II

MANAGING FORAGES FOR ANIMAL PRODUCTION

Brief Interpretation and Summary of Major Research

This section deals with some of the more important findings of the Virginia Forage Research Station. Detailed results of experiments are given in Section III.

Pastures

Work at the Station over the past 20 years has been directed toward finding the best management of pastures and supplements in feeding animals—beef and dairy cattle. We evaluated results in terms of cost of feeding the animals and achievement of optimum production.

Grasses and legumes in temperate humid regions usually furnish a diet for livestock that is high in proteins, minerals, and vitamins. The energy value of pastures, however, is too low for high production per animal. Cattle, horses, and sheep need 8 to 14 times more of energy, primarily fats and carbohydrates, than they do of protein. Available energy depends on the amount of intake and its digestibility.

We evaluated different grazing and fertilizing methods, and pasture mixtures, and found that adding energy by feeding grain increased the yield of meat or milk because steers and milk cows cannot obtain enough energy from pastures alone. High-energy corn-grain supplements were as good as high protein rations, even for dairy cows needing much protein for milk production.

It is important to get high yields of animal products per animal and per acre from pastures; but maximum values per animal and per acre cannot be obtained concurrently.

Light stocking of pastures allows selective grazing and improves daily meat or milk yield per head, but acre returns are low because much pasturage is wasted. With selective grazing, the animals eat more. The selected leafy plant parts they consume are high in energy and protein and low in fiber. On the other hand, very heavy stocking with little selective grazing lowers production per animal, causing low acre gains as well. The highest gains per acre occur with less than maximum production per head and reasonably good utilization of pastures. Thus, the stocking rate should be a wise compromise between maximum animal products per animal and maximum animal products per acre.

Steers grazing bluegrass-white clover pastures averaged 1.21 pounds daily and 312 pounds of liveweight gains per acre during ten years, as good as or better than they did on other pastures. Quality, shown by daily liveweight gains of steers, was similar for bluegrass-white clover, orchard-ladino clover, and orchardgrass-Korean annual lespedeza. For the grass-clover pastures, Kentucky 31 fescue-ladino clover gave the lowest gains per steer. Acre yields from the short-season lespedeza pastures were low; liveweight gains for the other grass-clover mixtures averaged more than 300 pounds per acre yearly during the ten years.

Grass pastures with 200 pounds nitrogen per acre each season produced feed to graze about 27 percent more cattle than grass-ladino clover pastures. However, steers, gained about 14 percent less when grazing nitrogen-fertilized grass than when grazing grass-clover pastures. The added cost of the nitrogen fertilizer was not justifiable as liveweight gains per acre were only about eight percent more for nitrogen-fertilized pastures than for grass-clover mixtures. Nitrogen fertilizer did not improve or reduce the palatability of grasses.

Steers grazing Ky. 31 fescue with nitrogen or fescue-clover pastures gained less than those grazing orchardgrass alone or with clover. The lower gains from Ky. 31 fescue are attributed to less consumption, caused by low palatability. Experiments with palatability showed that Ky. 31 fescue was the least, and timothy the most, palatable grass. Clovers improved the palatability of grasses. Although cattle prefer other grasses over Ky. 31 fescue, they eat it readily when there is no choice. Ky. 31 fescue is more satisfactory for brood cows and ewes than for producing high rates of liveweight gains or milk production. When nitrogen-fertilized, it resists freezing damage and furnishes more winter grazing than other grasses.

Several mixtures were tested with milk cows. Similar milk production per cow resulted from grazing alfalfa-orchardgrass, bluegrass-white clover-birdsfoot trefoil, and ladino clover-orchardgrass pastures. However, the alfalfa-grass pastures produced the most feed and therefore the most milk per acre.

Kenwell, a new and apparently palatable fescue variety, proved to be inferior to Ky. 31. During a four-year comparison, the 14 percent higher milk yield per cow grazing Ky. 31 fescue pastures was attributed to less pasture consumption for Kenwell. During the last two years, the cows grazing Kenwell had severe fescue foot, and some of the cows died.

Pastures may be grazed continuously or rotationally. Large, erect perennial plants such as alfalfa must be grazed rotationally with short grazing periods followed by long rest periods, to maintain stands and high yields. For small or prostrate plants, there is little advantage in grazing rotationally, unless stocking rates are heavy. The following of flush spring growth by low pasture yields during summer, and three to five months of winter dormancy, is a pasture problem. We found that rotational grazing can solve this problem as a part of a 12-month forage plan in which mixtures are used flexibly for grazing, silage and hay.

Liveweight gains or milk produced per head on continuous grazing may be higher or lower than on rotational grazing; however, if selective grazing is similar, animal performance on rotational and continuous grazing will be similar.

We used two groups of cattle, called first and last grazers, with rotational grazing. The first grazers, having fresh pastures, produced about 30 to 50 percent more milk or meat per head than the cows or steers that grazed the pasture residues. One can increase efficiency of production by giving high-producing animals first access to pastures. The residues would be grazed by dry stock or low producers.

A 12-Month Forage Program

Segregating pastures without making this part of an overall feed program is poor practice. Efficient livestock production requires that most of the pasturage be converted to livestock products. Pastures produce about two-thirds of their growth during the first third of the growing season. The common practice of understocking pastures in spring, because of low summer and fall yields, causes much of the spring growth to be wasted. The problem of pasture distribution is aggravated because growing calves or steers require much less feed (due to their small size) in the spring than later in the season. Thus, light stocking to assure a summer feed supply allows about half of the spring growth to become mature—with the result that cattle either refuse to eat it or tramp it into the soil. On the other hand, stocking pastures heavily to utilize the spring growth would cause a severe shortage of pasturage during the summer and fall months.

The solution to this problem, therefore, is a 12-month forage plan for silage, hay, and grazing utilization. This was put into effect by adjusting pasture acreage in spring to that needed by the cattle, and harvesting the flush spring growth for hay or silage. In a simple and practical plan at Middleburg, beef cattle were restricted to bluegrass or other pastures on the roughest land during spring, to enforce utilization. Heavy spring grazing kept the pastures in a leafy stage. The ungrazed pastures were mowed for hay; these could be grazed right after harvesting since mowers leave enough growth for grazing, especially with bluegrass pastures. Pasture normally wasted was saved, and about twice as much land was grazed in summer and autumn as in spring.

In a six-year experiment, a 12-month forage plan with perennial grass-legume mixtures, used flexibly for grazing and harvesting winter feed, produced enough per acre to feed a 700-pound yearling for 384 days. This was 72 percent more than with continuous grazing. Restricting cattle to limited areas during spring meant that the pasture was utilized; the fields not needed for grazing during spring were cut for hay or silage and then grazed in late summer and fall as needed.

Though there is not any one plan, this practice applies where there are peaks and shortages of growth. A specific 12-month feed plan should be developed for each farm after considering the enterprise, soils, equipment, storage facilities, and the farmer. Annuals and perennials may be used. Corn silage adds immensely to the quality and yield potential; hence, it should be used wherever adapted. Corn has first priority on soils adapted to grow it; when harvested as silage, it produced higher yields and higher utilizable energy than did the perennial grasses and legumes.

Silage and Hay

Hay crops: Because there is little or no winter growth in Virginia for several months, hay and silage crops are very important in feed programs and determine the number of cattle that can be carried on farms. Hay and silage crops should produce high yields that are highly palatable and digestible. Yields must be high if they are to lower harvesting and production costs. The cool and rainy spring season makes field drying of hay difficult, thus we harvest the first cutting at Middleburg for silage. Haymaking losses are minimized by using summer growths for hay.

During the first decade at Middleburg, we made efforts to improve hay- and silage-making and feeding with alfalfa - orchardgrass mixtures. Before the occurrence of alfalfa leaf weevil, this mixture was persistent and produced good yields. Early cuttings, when orchardgrass began to head, gave much better gains in steers than did late spring cuttings (orchardgrass in bloom). The early-cut mixture was leafier, more digestible, and consumed in larger amounts than were late cuttings. Alfalfa - orchardgrass fields remained productive for four to six years when early cutting was followed with three cuts in one-tenth bloom. The regrowth after four cuttings was often grazed after frost.

Alfalfa-grass silages were often objectionable because of smell; this was corrected by storing drier wilted silage. Direct-cut (high moisture) silage proved inferior to wilted (low moisture) silage. The steers gained only .3 pounds daily on direct cut silage, and 1.1 pounds on wilted silage. The higher gains for the wilted silage were attributed to higher consumption. When fed with corn silage, the steers ate wet and dry alfalfa-grass silages equally well.

Our endeavors to improve fermentation processes of alfalfa-orchardgrass silages by using antibiotics and sodium metabisulfite did not improve steer gains or milk production. Adding ground ear corn to direct-cut alfalfa-grass silage produced an excellent balanced ration that gave high gains. In the efforts to improve animal production from hay and silage of alfalfa-grass mixtures, it was necessary to supplement energy. However, the hay crop mixtures without supplements were satisfactory for brood cows and for wintering steers.

Corn silage: Corn silage made according to our research findings at Middleburg approaches an energy concentrate and should not be called a roughage. There is a potential yield of one ton of liveweight gain or 20,000 pounds of milk per acre from corn silage supplemented with a little protein. Feed costs per pound of liveweight gain amount to about 12¢, and per pound of milk about 2.5¢. The high yields of livestock products per acre from corn silage occur because: (1) The entire plant is harvested, adding about 35 percent to the yield as compared with grain harvesting. (2) Corn yields have been consistently high. (3) The field and storage losses are very low—the high sugar content causes quick fermentation to a low acidity that minimizes storage losses. (4) The silage invariably has a desirable odor and is high in energy value (TDN). (5) The intake has been consistently high averaging more than 2 percent and up to 3 percent of liveweight (2 or 3 pounds of dry matter per 100 pounds of bodyweight). (6) The high intake and digestibility causes high liveweight gains or milk production. (7) With excellent animal production, proportionately less of the feed is used for maintenance; thus, the efficiency of feed utilization is increased.

Corn silage has consistently given excellent results with steers, milk cows, calves. Steers with stilbestrol implants, full-fed corn silage with a little protein meal or urea, gained up to 2.7 pounds daily during 150 days and produced carcasses similar in quality to those for high gain rations. Weaned beef and dairy calves weighing 300 pounds or more have gained about 1.75 pounds daily on corn silage supplemented with protein meal. High-silage and given protein supplement produce as much milk as cows receiving a liberal 18 percent protein-producing milk cows full-fed on corn concentrate mixture supplement.

Such quality corn silage must come from a high grain hybrid; the best grain variety is also the best silage variety. The crop should be cut in a hard dent stage when the silage dry matter is between 36 and 42 percent. Daily consumption increases as silage dry matter increases up to about 42 percent dry matter. Such corn silage is harvested when the dry matter yields approach maximum. Corn silage cut early in a milk stage or very late near maturity is high in digestibility, but consumption is less than for silage stored at 36-42 percent dry matter. For example, the liveweight gains averaged 2.4 for late milke stage, 2.7 for hard dent, and 2.4 pounds daily per steer for silage when the grain was nearly mature.

Other silages: Silage from sudan sorghum hybrids cut when 30 inches high and wilted was nearly as good as corn silage. However, harvesting costs for such a low-yielding crop are high. Late-cut sudan-sorghum hybrids were low in digestibility and consumption as compared with corn. Small grain silages had to be supplemented with a grain-protein mixture to obtain good gains or milk production. The digestibility (TDN) and intake is lower than that of corn silage.

Raising Calves Efficiently

We use an Angus cow herd to study management and feeding methods of cows and their calves; steers and heifers are used to evaluate pastures and forages with the idea of reducing costs of production. Economic data show that profit margins are usually better for steer production than for raising calves. Costs of raising calves can be reduced in two ways: (1) raising a near 100 percent calf crop and (2) reducing the feed costs per cow-calf unit or raised calf.

July-August calving at Middleburg has averaged over a 90 percent raised calf crop, except for one year when *Leptospirosis* caused abortions. Summer calving makes it simple to study separate rations for calves and cows in order to figure production costs. The growth of calves during the first three months depends largely on the cow's milk; after this, feed other than milk is most important. One cannot afford to feed cows liberally to produce milk to raise calves. For example, the gains of nursing creep-fed calves, three to eight months old, were about 2 pounds daily when cows were full-fed or 75 percent full-fed (Figure 1). Cows may lose more than a pound daily without influencing the gains of such nursing creep-fed calves. On the other hand, when cows were full-fed on balanced rations, the nursing calves getting milk gained only one-third of a pound daily. Calves restricted to cow's milk were thin and stayed very hungry.

We found that costs of raising calves can be reduced by feeding rations high in forage, especially corn silage. (Figure 2.) When the calves had milk and ate with cows, calf gains were one-third less than with creep feeding. Without creep feeding, the calves had to compete with the mother cows for feed. When creep-fed calves were allowed to eat with cows, they ate enough of the cows' feed to cause excessive weight losses of the mother cows.

Calves weaned at the fourth month gained about 1.7 pounds daily for the next four months as compared with two pounds or more for unweaned creep-fed calves. Some milk is necessary for fast growth of calves, but the amount need not be high when calves have plenty of good feed.

It is clear that well-fed beef cows cannot produce enough milk for fast-growing calves that are several months old. When calves were restricted to their mother's milk, 44 pounds of total digestible nutrients (TDN) were needed per pound of calf gain. Creep-fed nursing calves needed only nine pounds of TDN (about 17 pounds of hay) per pound of gain. Thus, the costs of raising calves were sharply reduced by limiting feed to the cows and feeding calves quality forage rations to get good gains.

Very low daily feed rations may be used for cows with calves. Two

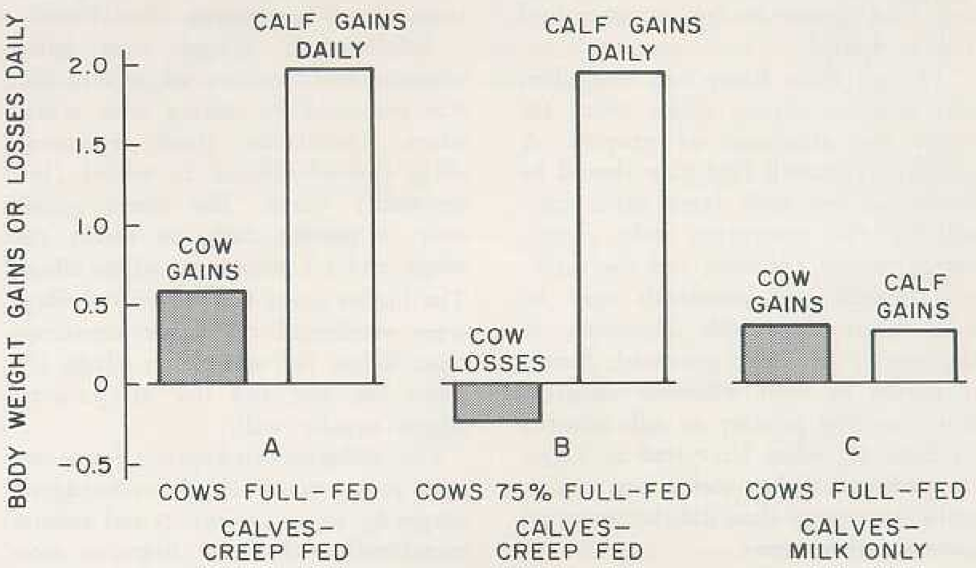


FIGURE 1. This shows that liberal feeding of cows to get more milk does not improve the gains of calves. Compare A & B. When calves got only milk from mother cows, gains were only .33 lb. as compared to 2 lbs. per day for creep-fed calves (compare A with B & C).

SECTION III

MANAGING FORAGES FOR ANIMAL PRODUCTION

Major Research Findings in Detail

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PASTURE INVESTIGATIONS

Pasture experiments with beef and dairy cattle serving as experimental animals were designed to obtain practical data and establish principles for utilizing pastures more efficiently. Species, mixtures, palatability, grazing methods, and stocking are evaluated. The following data are presented to describe desirable practices and principles. We are reporting results obtained with both beef and dairy cattle, since they respond similarly to nutritional and management factors in pasture utilization.

Meat Production from Grass-Clover Mixtures and Nitrogen-Fertilized Grasses

Six pasture treatments were evaluated. Four were Virginia orchardgrass and Kentucky 31 fescue, both nitrogen-fertilized and with ladino clover; the other two were annual Korean lespedeza - orchardgrass and Kentucky bluegrass-white clover pastures (Table 1).

After liming and fertilizing the six pasture treatments were seeded in August, 1949; phosphorus and potassium were applied yearly after 1950. The N-fertilized pastures had 200 pounds of N per acre yearly, split into four applications. The pastures were fenced with four sublots for rotational grazing with steers. The data using fat Angus heifers for the first grazing season are excluded.

Pasture Quality-Daily Gains Per Steer: Liveweight gains per steer were best for orchardgrass-ladino clover, bluegrass-white clover, and the Korean lespedeza-orchardgrass pastures (Table 1). These pastures gave similar results. Gains per steer were consistently lower during ten years with Ky. 31 fescue-ladino clover than for the other grass-clover pastures. Steers grazing the two grass-ladino clover mixtures gained about 17 percent more than when grazing the grasses with N fertilizer. Steers on orchardgrass pastures (alone with N and with clover) gained 21 percent more than on the fescue pastures. These results were quite consistent during ten years (Figure 3).

The low liveweight gains of steers grazing the fescue pastures is attributed to the lower consumption of fescue, since it is low in palatability. Poor clover stands in fescue also reduced the nutritional value of that pasture. It is more difficult to maintain clover with tall fescue than with the other grasses. Fescue is aggressively competitive because it grows in drier, cooler, and warmer environments than clover. Because of low palatability and therefore less grazing, the dense fescue sods inhibit clover stands.

The higher liveweight gains from grass-clover than for nitrogen fertilized grasses cannot be explained. Clover may improve the digestibility and consumption of pasture and may also furnish hormone-like substances that stimulate animal production.

The orchardgrass-lespedeza pastures were primarily orchardgrass-lespedeza pastures for only two years; white clover, from hard seeds naturally in the soil and seed introduced through cattle feces, made up much of the sod by the third year. This mixture, being similar to orchardgrass-ladino clover, was not grazed after the sixth year. Data for five years show that liveweight gains per acre were about 25 percent less for the orchard-lespedeza-white clover than the orchard-ladino pastures (Table 1.)

Pasture Season and Steers per Acre: Grazing began with meager growth in early April and usually ended in October or November. Ky. 31 fescue pastures with nitrogen furnished the longest grazing season and those with lespedeza the shortest. Bluegrass pastures gave a longer season than orchardgrass, since orchardgrass made less growth than bluegrass during the late summer-autumn season.

Steer days of grazing each year (not length of season) is a good estimate of total pasture production. The grass-clover pastures during ten years furnished feed for 257 to 303 steers days per acre (Table 1). Kentucky 31 fescue-ladino clover produced more pasturage than the other clover-grass mixtures. The carrying capacity of the orchardgrass-lespedeza pastures was very low but improved as white clover encroached.

Nitrogen fertilizer caused sharp yield increases of grass pastures; there was 27 percent more grazing for N-fertilized grass than grass-clover pastures. Fescue pastures (N-fertilized) produced feed for 403 steer days grazing per acre per year during ten years (Table 1).

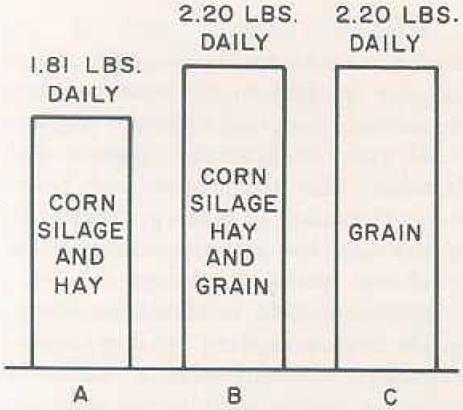


FIGURE 2. Calves getting milk with high forage creep-fed rations made good daily gains.

groups of cows with moderate and very low feed rations, during four to eight months after calving, lost 0.13 and 1.19 pounds daily per cow. The calves having creep feed at all times gained at similar rates of about two pounds daily. Loss of as much as 1.5 pounds daily per cow during four to eight months after calving, followed with very good pasture has not reduced calving rate, calf birthweights, nor its growth.

Cows with three-month or older calves can be fed low rations, if the calves are separated from the cows while eating. A labor-saving fence-line nursing system, where cows and calves are in adjacent lots, was developed. Such calves gained 2.0 pounds daily and nursed less often than those that stayed with cows. When weaning the calves, the openings in the board-nursing fence were closed. This procedure made weaning simple; there was slight lowing by cows or calves and the calves continued to gain weight.

Pastures for Horses

Pastures furnish excellent natural sources of protein, minerals, vitamins, and energy for good nutrition of horses. In addition, pastures encourage exercise, aiding vigor, endurance, and health of horses. The climate in Virginia furnishes a long pasture season and is favorable for growing mixtures of bluegrass, orchardgrass, and white clover, that are of excellent nutritional quality and highly palatable for horses. Pastures grown on Virginia soils are adequately high in trace minerals such as copper, zinc, and manganese. Dolomitic limestone to correct soil acidity and supply calcium and magnesium along with phosphorus and potassium, must usually be applied to support balanced mixtures of grasses and clover. Lime and fertilizer needs vary with soils and residual effects of materials previously applied. All soils in Virginia are low in nitrogen, a growth stimulator, and a major constituent of protein; thus, clover in pastures stimulates yields and improves protein, minerals, and vitamins.

In northern Virginia, bluegrass-white clover pastures are especially suitable for horse pastures because they form dense sods free of clumpiness, provide high nutritional quality, persist under close grazing, and are adapted to freezing and warm temperatures, making for long grazing seasons. In the absence of perennial unpalatable weeds, blue-grass-white clover pastures can be maintained indefinitely without plowing and reseeding. The grass-clover balance and leafiness depends on grazing management and adequate liming and fertilization.

Adaptation and Culture of Grasses and Legumes

Pastures and hay crops are not natural in the humid East and Virginia; the natural vegetation is a forest complex. Neglected or mismanaged sod crops, through a series of changes in vegetation, revert to forests. All perennial grasses and legumes now used for pastures and hay crops in Virginia were introduced. Success in producing high yields of good quality and maintaining stands depends on man's knowledge and how he handles the interplay of soil, plant, and animal factors.

Perennial grasses and legumes, introduced many years ago, are almost always better adapted than new introduced species from abroad. Through natural selection, the plants introduced many years ago have become adapted and persistent under the climatic, soil, disease, and insect complex of the new world.

The best adapted perennial grasses and legumes include varieties of alfalfa, red clover, white and ladino clovers, Kentucky bluegrass, orchardgrass, tall fescue, and timothy. Annual Korean lespedeza grows best where there is limited plant competition during spring, as on soils with low fertility or restricted applications of fertilizer. Bromegrass and birdsfoot trefoil are very susceptible to a summer disease *Rhizoctonia* that is often fatal. Crownvetch, a legume slow to establish and unpalatable because of high tannin, is under study. Warm season grasses such as Coastal and Midland bermudagrasses have winter-killed at Middleburg.

We find that even the best perennials are rather inefficient; they produce about half as much dry matter as corn, even though corn is a short season crop. Yields per acre of perennials grasses and legumes have improved little as compared with sharp increases in corn yields. Under good management, alfalfa stands last longer and yield more than other legumes. Grasses with liberal nitrogen fertilization yield no more than alfalfa. Because of low yield potentials, the present varieties of perennial grasses and legumes are best suited to untillable lands where corn cannot be grown.

The reasons for the rather low rates of dry matter accumulation of temperate perennial sod crops are still uncertain but the rates are attributed to inefficient photosynthesis that is further restricted by warm temperatures. Water shortage caused by low and poor distribution of rainfall causes slow growth of sod crop plants. The shallow roots of many sod plants and intense shading in lower canopy layers restricts dry matter production and accumulation rates. Shaded dropping leaves cause dry matter losses.

Mixtures of Grasses and Legumes

Soil nitrogen being low in Virginia, it is practical to grow nitrogen-fixing legumes alone or in grass mixtures. Mixtures give some nutritional, utilization, and yield advantages; but it is easier to manage nitrogen fertilized grasses than legumes or grass-legume mixtures. Legumes are vulnerable to diseases, insects, drought, adverse temperatures, low fertility, and bad management. The severe competition between grasses and legumes in mixtures for light, water, and soil nutrients is often difficult to understand and to handle for obtaining high yields, good quality, and a balance of grasses and legumes.

Our research has helped design suitable seed mixtures and establish good management principles for establishing new seedings and maintaining mixed stands of good quality forage. Successful establishment of sod crops begins with adequate liming and fertilizing and choosing a legume or mixture adapted to soil conditions such as drainage. For soils low in phosphorus, liberal amounts improve seedling growth during establishment and later yields. Grasses are aggressive competitors for potassium; thus, on soils low in available potassium, legume-grass stands become grassy.

We found severe competition among seedling communities of grasses and legumes. Because of high germination, rapid emergence and fast growth, seedlings of certain species are very aggressive toward others. The relative aggressiveness of seedlings varies with spring and summer sowing. Because of cool temperatures and favorable moisture in spring as compared with summer, grasses are more aggressive with spring than with summer sowing. Alfalfa is especially easy to establish in the summer. Adjustments should be made in seeding rates and with season of sowing among species to compensate for aggressiveness.

It is wrong to suppose that complex mixtures are ideal because species adapted to wide ranges of climatic, soil, and biotic conditions may be included, giving the highest possible yields over a long season. The truth is that most of the species would be eliminated during seedling competition; finally, there would be sparse stands of adapted plants and low yields.

Maintaining stands of adapted perennial grasses and legumes depends on lime, fertilizer, pest control, and cutting or grazing management. Fertility programs should support maximum economic yields of the legume or mixture to be grown. Cutting or grazing management is very important in controlling quality, yield, and balance of grasses and legumes. The frequencies and closeness of cutting or grazing varies with plants and has a major influence on yield and quality of forage.

It is impossible to obtain maximum yields and maximum quality simultaneously. Cutting alfalfa whenever it is 10 inches high produces a superior hay high in disgestibility, protein, minerals, and palatability. Yields will, however, be low with stands lasting one year. On the other hand, cutting three or four times yearly gives near-maximum yields, but forage quality is much better with four annual cuttings. Ladino clover-orchardgrass mixtures, however, may be utilized in leafy growth stages when quality is high. Nevertheless, very close grazing with near-complete leaf removal causes slow regrowth, because leaf areas are too small for high photosynthesis. In addition, close grazing removes the insulating effect of the sod, causing high temperatures that increase respiration and restrict photosynthesis. Hence, decreased carbohydrates, high temperatures, and small leaf areas cause a sharp decline in regrowth and yield.

Liveweight yields per acre: Liveweight gains per acre depend on daily gains (pasture quality) and on steer days grazing each year per acre. The three grass-clover mixtures produced similar liveweight gains ranging from 309 to 329 pounds per acre (Table 1). The orchardgrass-lespedeza pastures produced the lowest gains per acre. The highest liveweight gains per acre with N-fertilized fescue were only 14 percent more than for the fescue-ladino clover pastures. The low daily gains of steers grazing N-fertilized grass pastures caused the low liveweight gains per acre. Gains per acre were too low to make N applications practical.

Longevity of Sods: Pastures with Ky. 31 fescue or bluegrass had excellent sods with little weed encroachment during 11 years. Orchardgrass- ladino clover sod was quite satisfactory, but weeds encroached. Stand losses of N-fertilized orchardgrass were severe; hence, these pastures were very weedy during the 11th year. Korean lespedeza stands were good for two years; later the flush spring clover and grass growth shaded out most of the annual lespedeza seedlings.

White and ladino clover stand losses were apparently caused by a combination of factors—drought, diseases, and winter heaving causing desiccation. The *degeneration* of tap roots with age also makes white clover vulnerable to drought, as clover with shallow stolon roots lacks persistence. When stands were poor, white or ladino clover at three pounds per acre were seeded with a grain drill in late winter. One year the seed was surface broadcast in March. Early heavy grazing prevented severe light competition from the grasses and aided in establishing the clover seedlings. These reseedings contributed substantially by late spring and were inexpensive to maintain. Sods should be grazed closely during the autumn preceding the spring of seeding clover without tillage.

Seasonal Production of Pastures: Stocking was adjusted to utilize the growth of all pastures as the season advanced. There was pasturage to graze two or three steers per acre during the spring months, one or more from July to October, and a further decline in pasture production during October and November (Figure 4). Lespedeza-orchardgrass pastures were lowest and N-fertilized fescue pastures were highest in production. The low summer production is attributed to moisture shortage; and temperatures may also have been too high for high rates of photosynthesis.

IT TAKES A LOT OF FEED: Pasturage should be very palatable so that milk cows or steers eat a lot every day. A large dairy cow should eat around 150 lbs. of pasture each day.

Milk Production from Tall Fescue Varieties

We seeded Kenwell (a new tall fescue variety) and Ky. 31 tall fescues in pure stands and fertilized annually with 200 pounds N/acre/year to get critical data on milk production with Holstein cows. The nitrogen was applied in several split applications each year. The soil was limed to above pH 6 and fertilized with phosphorus and potassium. The grasses were sown in 4.6 acre pastures replicated two times and grazed rotationally.

The cows were selected in similar groups of six and randomized to the fescue pastures; cows on each pasture were fed three rates of grain—none, 1:9, 1:3 (pounds grain : pounds milk). These feeding rates were not altered even though milk production decreased. During one of the years, the concentrate milk ratios were 1:8, 1:4, and 1:2 when grazing was started and reduced two percent per week.

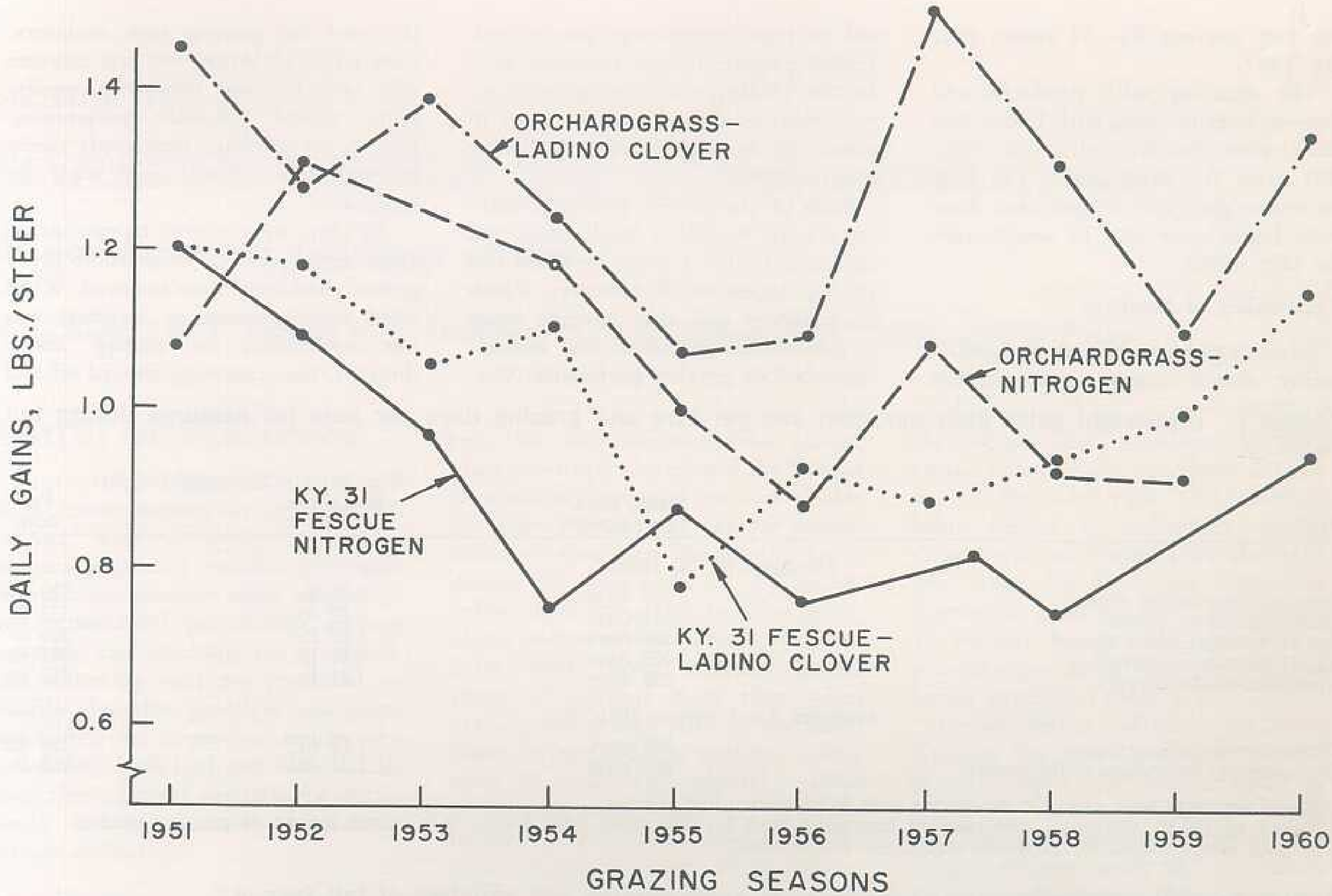


FIGURE 3. Pastures with fescue produced lower gains than those with orchardgrass. Ladino clover with the grasses improved the gains as compared with the nitrogen fertilized grasses.

Pasture Quality-Milk Production and Body Weights: Milk per cow daily averaged for the first three years shows that Kenwell fescue produced 21% less than Ky. 31 fescue (Table 2).[1] Without grain feeding, there was about 6.3 lbs. more milk daily per cow for Ky. 31 fescue than for Kenwell. Milk production[1] increased with grain feeding, but Kenwell was consistently inferior to Ky. 31 fescue in these 3-year experiments. During 1966, with liberal grain feeding, milk production per cow was also consistently less with Kenwell than for Ky. 31 fescue. When averaging all grain feeding rates, there was 9% more milk daily for Ky. 31 than for Kenwell fescue (Table 2).

[1] All milk data refer to 4% fat corrected milk unless otherwise stated.

During the first three years for all concentrate feeding rates, the cows grazing Ky. 31 gained 16 lbs.; those on Kenwell fescue lost 53 lbs. During the last year, with liberal concentrate feeding, the average bodyweight losses per cow were 18 lbs. for Ky. 31 and 75 lbs. for Kenwell fescue.

The dry matter digestibilities of the two fescues were similar (Table 3). However, the cows consumed 0.49 lbs. more pasture dry matter per 100 lbs. of liveweight from Ky. 31 than from Kenwell fescue (Table 4). The higher milk production and liveweight maintenance with Ky. 31 as compared with Kenwell fescue may be attributed to differences in dry matter consumption and fescue foot affliction when grazing Kenwell fescue.

Fescue Foot: A fescue toxicity known as "fescue foot" has occurred with tall fescue pastures. We have not encountered fescue foot with the Ky. 31 fescue variety with beef or dairy cattle at Middleburg; fortunately, it has not been a serious problem in Virginia.

During 1965 and 1966, cows on two Kenwell fescue pasture had severe attacks of fescue foot. Milk production dropped sharply during mid-summer. The cows became lame from sore feet or cracked hoofs, became emaciated, and some cows lost the ends of their tails. A few did not recover, some recovered partially, and others died. Grain concentrate feeding did not influence this toxicity. There was possibly a slight toxicity sympton with one cow grazing Ky. 31 fescue during 1965.

The data on milk produced and liveweight gains along with fescue foot clearly show that Kenwell is not a suitable grass for dairy cows. The data on liveweight gains suggest that Kenwell fescue may not be satisfactory for beef cattle.

Palatability of Pastures

Grazing pastures of preferred palatability should improve consumption and increase production per animal. Added pasture intake increases production efficiency because proportionately more of the feed is converted to animal products and less is used for maintenance.

Each of the pasture species or mixtures were seeded in small plots and surrounded with a fence so steers had grazing access to all mixtures. Yields taken before and after grazing made it possible to calculate the amount consumed or grazing preference. Cattle, used for grazing each enclosure, were removed before any one mixture was grazed close; otherwise, availability would influence preferences. Four to six grazings were made yearly in two experiments, each with six repetions.

All plots were mowed to two inches after each grazing to promote leafy growth, and feces were removed. When weed encroachment or leafiness was not controlled, or during severe drought, the areas were mowed off and

TABLE 1. Liveweight gains daily per steer and per acre and grazing days per acre for pastures during ten years.

Pasture	Steer days per acre**	Liveweight Gains: Daily per steer	Liveweight Gains: Per acre
	Averages for 10 years		
Orchardgrass-ladino clover	257 days	1.28 lb.	329 lb.
Orchardgrass-no clover*	311 days	1.07 lb.	333 lb.
Ky. 31 fescue-Ladino clover	303 days	1.02 lb.	309 lb.
Ky. 31 fescue-no clover*	403 days	0.91 lb.	367 lb.
Bluegrass-white clover	258 days	1.21 lb.	312 lb.
	Averages for 5 years—1951-'55		
Orchardgrass-ladino clover	258 days	1.28 lb.	330 lb.
Orchardgrass-lespedeza-white clover	204 days	1.31 lb.	268 lb.

*Fertilized each year with 200 lbs/N per acre from ammonium nitrate.
**Based on 700-lb. yearlings—the pasture furnished feed for the steer days given; this is not length of grazing season. The data are averages for pastures replicated three times.

TABLE 2. Milk production and liveweights of cows grazing two varieties of tall fescue.*

Tall Fescue variety and grain: milk ratios	Milk per cow daily: Before grazing (Standardization) Lbs.	Milk per cow daily: While grazing (Experimental) Lbs.	Relative persistency of milk production (Exper./Stand. x 100)	Liveweight changes
	During three grazing seasons—1963-65			
Ky. 31 fescue				
0 (0)*	42.0	29.5	70	+12
1:9 (1:7.7)	36.6	30.1	82	− 1
1:3 (1:2.8)	45.7	38.5	84	+37
Average	41.4	32.7	78	+16
Kenwell fescue				
0 0	43.0	23.2	54	−85
1:9 (1:5.7)	43.5	26.7	61	−64
1:3 (1:2.1)	45.1	31.0	69	−11
Average	43.8	27.0	61	−53
	During 1966 grazing season			
Ky. 31 fescue				
1:8	52.0	35.9	69	−18
1:4	53.9	42.1	78	−24
1:2	71.0	55.3	78	−13
Average	58.7	44.4	76	−18
Kenwell fescue				
1:8	52.0	33.5	64	−102
1:4	56.4	38.1	68	−74
1:2	69.5	50.1	72	−48
Average	59.3	40.6	68	−75

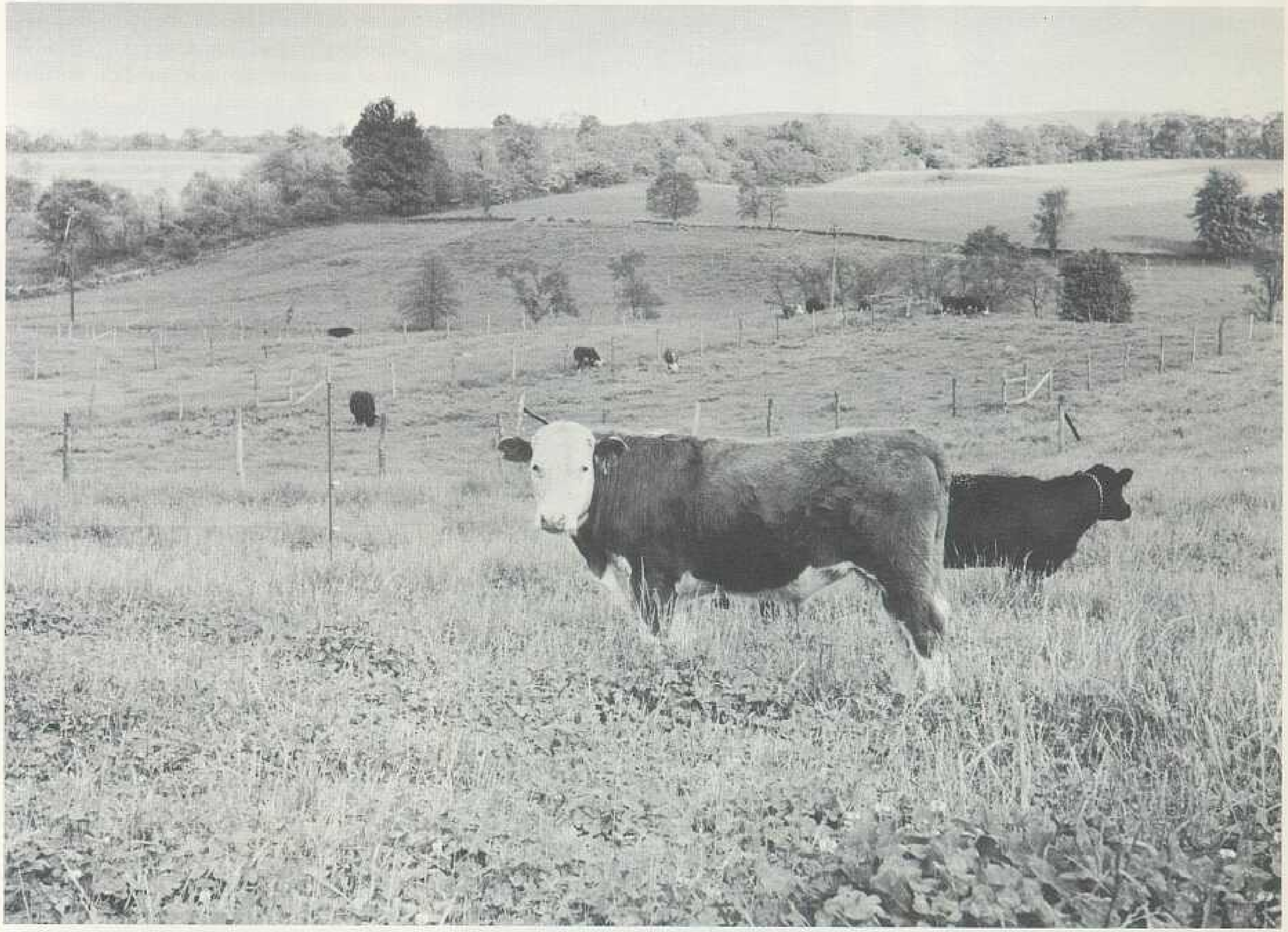
( ) actual grain : milk ratios
*There were two replications of the pastures each year.

grazed later. Steers accustomed to grazing in small lots were used. Restricting the grazing periods to several hours avoided excessive trampling and fouling of plots.

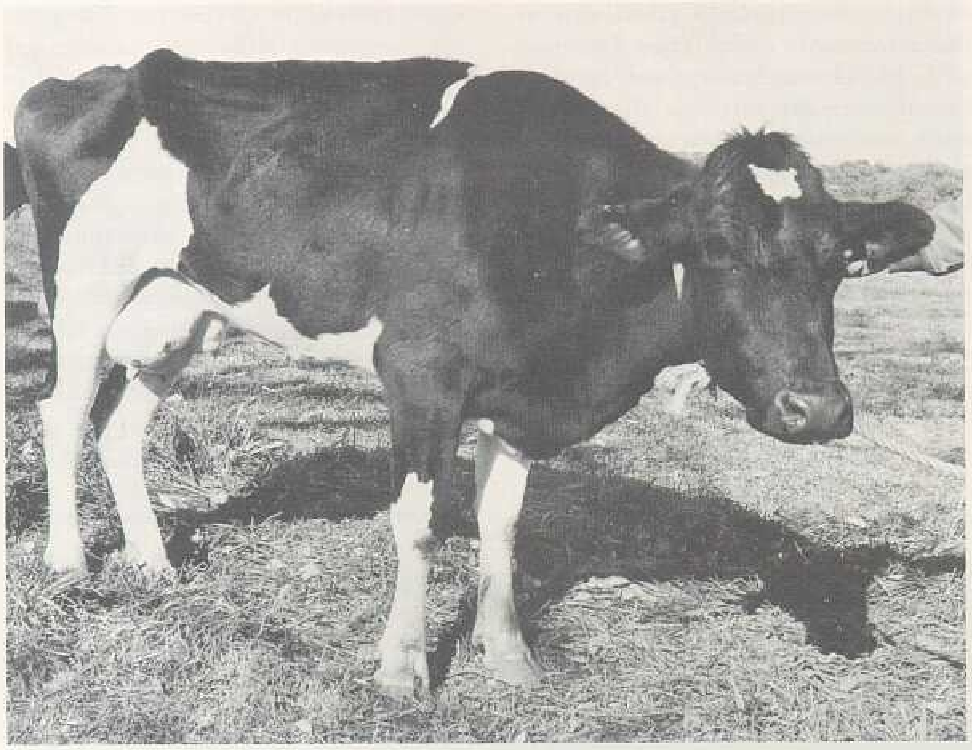
Palatability of Grasses and Grasses with Clover: The pasture species and mixtures evaluated with steers, described at the beginning of this section, were used. During three years, orchardgrass with ladino clover was consistently highest and Ky. 31 fescue N-fertilized was the least palatable (Table 4) Ky. 31 fescue produced the highest yield, but steers consumed only 25% of the herbage. The ladino clover with orchardgrass or Ky. 31 fescue improved the palatability as compared with either grass fertilized with N. Orchardgrass alone or with clover was more palatable than fescue with the same treatments. The orchardgrass-lespedeza-white clover mixture was high in palatability and the values for bluegrass-white clover pastures were intermediate. These results help explain differences in animal gains as previously noted.

Palatability of Grasses with Rates of Nitrogen: Growth, color, and appearance of the grasses improved with added increments of nitrogen. However, palatability as shown by grazing performance was similar for the three rates of N (Table 5). The grazing preference of five grasses averaged for three rates of nitrogen shows that timothy was the most and Ky. 31 fescue the least palatable. These results generally agree with other observations at Middleburg.

The protein content when nitrogen fertilizer was added, increased for all grasses. However, nitrogen stimulates growth, causing reductions in soluble carbohyydates (sugars and starchlike fructosans). Grass with low as compared to high rates of nitrogen may at times be favored in palatability because of the shorter growth and higher soluble carbohydrates. That ni-



GENERAL VIEW OF GRAZING EXPERIMENT: There were 18 pastures; six pasture treatments repeated three times. Each pasture was grazed rotationally with a different group of steers making 72 pastures in the experiment.



FESCUEFOOT OF KENWELL FESCUE: Fescuefoot occurred during 2 successive years when cows grazed a new variety of Kenwell tall fescue. The cows lost weight very rapidly and became lame in the rear feet caused by cracked hoofs shown in lower photo. Steers and dairy cows grazing Kentucky 31 fescue have not been afflicted with fescuefoot at Middleburg.

trogen fertilization did not increase nor decrease palatability generally agrees with animal performance data. Nitrogen does not usually increase nor decrease the digestibility of grasses nor the output of products per animal. However, yields per acre are increased.

The grazing results, previously noted, showing lower steer gains with N-fertilized grasses than for grass-clover mixtures and lower gains with fescue than orchardgrass pastures, generally agree with palatability data, since low palatability depresses consumption. A supplementary experiment showed that the digestibility of orchardgrass and Ky. 31 fescue were similar but heifers consumed much more orchardgrass. However, the palatability values for bluegrass alone or in a mixture do not predict pasture intake and animal output. The bluegrass pastures were not mowed close enough to measure dry matter production, also the steers grazed below the mowing height, thus the yield and amount grazed may have been underestimated.

Application to Management: For practical grazing management, fescue or any plant low in palatability should be kept in a young, leafy stage of growth when quality and intake is highest. Fescue by itself or with legume mixtures should be in separate fenced pastures. Where it can be managed to maintain young, succulent growth. If used in pasture mixtures with palatable grasses, fescue will soon dominate the sod, because it is not grazed closely. Many farmers have used Ky. 31 fescue-orchardgrass-ladino clover mixtures or seeded orchardgrass and fescue in adjacent strips where cattle had access to both grasses. In such situations, the orchardgrass, high in palatability, was grazed closely and the fescue remained ungrazed.

Unpalatable grasses must be stocked heavily to maintain leafiness. There is often extreme over-and under-grazing with continuous grazing. Utilization may be improved by mowing to encourage leafiness or by using rotational grazing.

Palatability studies cannot be substituted for grazing experiments. Though palatability data suggest that tall fescue is very inferior, milk production and animal gains are satisfactory. If cattle are restricted to tall fescue pasturage, they readily adjust to grazing it, especially when it is in a young leafy condition. The less palatable grasses such as fescue are especially suitable for brood cows.

Milk Per Cow From Pasture and Hay With Rates of Supplements

This experiment was planned to measure milk production with (1) pasture only, (2) pasture during the night hours with hay in shaded dry lot during day, and (3) hay in dry lot day and night. Three rates of concentrate supplements were also investigated (Figure 5). The pasture was mainly bluegrass-white clover, but small grains were grazed during early spring and alfalfa-orchardgrass during part of the summer. Excellent quality alfalfa-orchardgrass hay was fed at 15% excess of consumption.

The average of milk produced daily during two seasons for all concentrate feeds, was 16 percent more for pasture than for good quality alfalfa hay (Figure 5). Without concentrates, the cows on pasture produced 42.2 lbs. of milk daily, 35 percent more than for hay. Cows fed at a low concentrate rate, 1 lb. to 8 of milk, produced considerably more milk on pasture than on hay. With liberal concentrates, milk production per cow daily for the pasture and hay was similar. Feeding hay during days and pasture at nights was inferior to pasture alone.

Pasturage was generally superior to hay because: (a) the leafy young growth of pastures is higher in digestibility, protein, minerals, and vitamins than hay, which is cut in later stages of maturity when the crop is stemmy, and (b) dry matter digestibility of ingested pasturage is high

TABLE 3. The digestibility and intake of pasturage by cows grazing two varieties of tall fescue, 1963-1965.

Seasons	Ky. 31 Fescue Dry Matter Digestibility %	Ky. 31 Fescue Dry Matter Intake Lbs.	Kenwell Fescue Dry Matter Digestibility %	Kenwell Fescue Dry Matter Intake Lbs.
Spring	61.7	26.8	62.4	23.4
Summer	64.0	30.0	62.4	22.6
Fall	64.6	30.1	64.0	23.6
Average	63.4	29.0	62.9	23.2
Dry matter per 100 lb. liveweight		2.73		2.24

TABLE 4. Dry matter yields (grazable herbage) and amount grazed for pasture treatments during three years, 1950-52.[3]

Pasture treatment	Pasturage per acre: Grazeable yield	Amount grazed[1]	Percent grazed
Orchardgrass-ladino clover	3773 lbs.	2276 lbs.	60%
Orchardgrass-no clover[2]	5310 lbs.	2395 lbs.	45%
Ky. 31 fescue-ladino clover	3970 lbs.	1773 lbs.	45%
Ky. 31 fescue-no clover[2]	5662 lbs.	1417 lbs.	25%
Bluegrass-white clover	2800 lbs,	1125 lbs.	40%
Orchardgrass-lespedeza-white clover	2465 lbs.	1313 lbs.	53%

[1]The cattle were removed before any mixture was consumed so that available supply would not seriously interfere with grazing preference.

[2]Fertilized each year with about 200/N per acre as ammonium nitrate.

[3]There were a total of 15 grazings (five in 1950, four in 1951, and six in 1952). Each averaged for six replications. Total yields were higher than grazeable yields shown as some growths were not grazed.

TABLE 5. The grazing preferences of grasses fertilized with three rates of nitrogen and of five grasses (averaged for three rates of N) during three years, 1950-52.

Treatments	Grazeable herbage Lbs./A	Amount grazed Lbs./A	Percent of available herbage grazed
Influence of nitrogen fertilizer on grazing preference*			
35 lbs. N/A	1210	480	39
70 lbs. N/A	1840	670	36
140 lbs. N/A	2630	1080	41
The grazing preference of five grasses**			
Orchard	2110	940	44
Brome	1660	660	39
Timothy	1780	900	50
Ky. bluegrass	1740	540	31
Ky. 31 fescue	2280	670	29

*Each value is an average of 55 trials (11 grazings and 5 grasses).

**Each value is an average for 33 trials (11 grazings and 3 nitrogen rates). In addition, all values are averages of six replications.

because of selective grazing. (See the following section on Rotational Grazing.) The dry matter digestibility of pasturage was excellent, 72.4% in 1962; because of drought and fewer legumes, the value was 66.2% in 1963. However, the concentrate supplements increased milk production for all pasture and hay treatments because the energy content of forages especially of hay was inadequate.

Feeding Grain and Protein on Pastures

Meat and milk production per head is rarely limited by digestible protein in well managed perennial grass-legume pastures in Virginia. However, output per animal on the best managed pastures can be substantially improved by supplementing high energy grains. The energy requirements are 8 to 10 times higher than the protein needs for high producing animals. Whether perennial grasses and legumes are used for silage, hay, or pasture, the amount eaten and its digestibility does not furnish enough energy for maximum animal outputs.

Steer Gains with and without Grain: Beginning in April, bluegrass pastures were stocked with weanlings and yearlings under continuous grazing for the season. Starting in mid-June, ground shelled corn was fed daily at mid-day at a low rate (1% of the liveweight); other steers had pasture alone all season for three years.

Low rates of grain feeding to steers on pasture improved gains over pasture alone (Figure 6). Pastures did not supply enough energy for best gains. The young steers, weaned in spring, were fat, as they were fed to gain almost 2 lb. daily before being pastured and the yearlings had gained only about .6 lbs. daily. Thus, the long yearlings gained more than the weanlings on pasture because they lacked fatness; and their age and size may also have contributed to the higher gains.

Feeding grain makes it possible to stock more heavily and achieve better herbage utilization without sacrificing rate of liveweight gains. It will also shorten the period for producing marketable steers. During the spring flush pasture growth, when pasture digestibility is highest, it is not usually practical to feed grain to the cattle. Additional weight gains from grain feeding would likely be nil or small and this would add to the wasted pasturage so commonly experienced. However, with fat cattle such as the weanlings, grain feeding during the flush pasture period would generally improve liveweight gains.

These results do not necessarily show that it is practical to feed grain on pastures. All steers were fattened

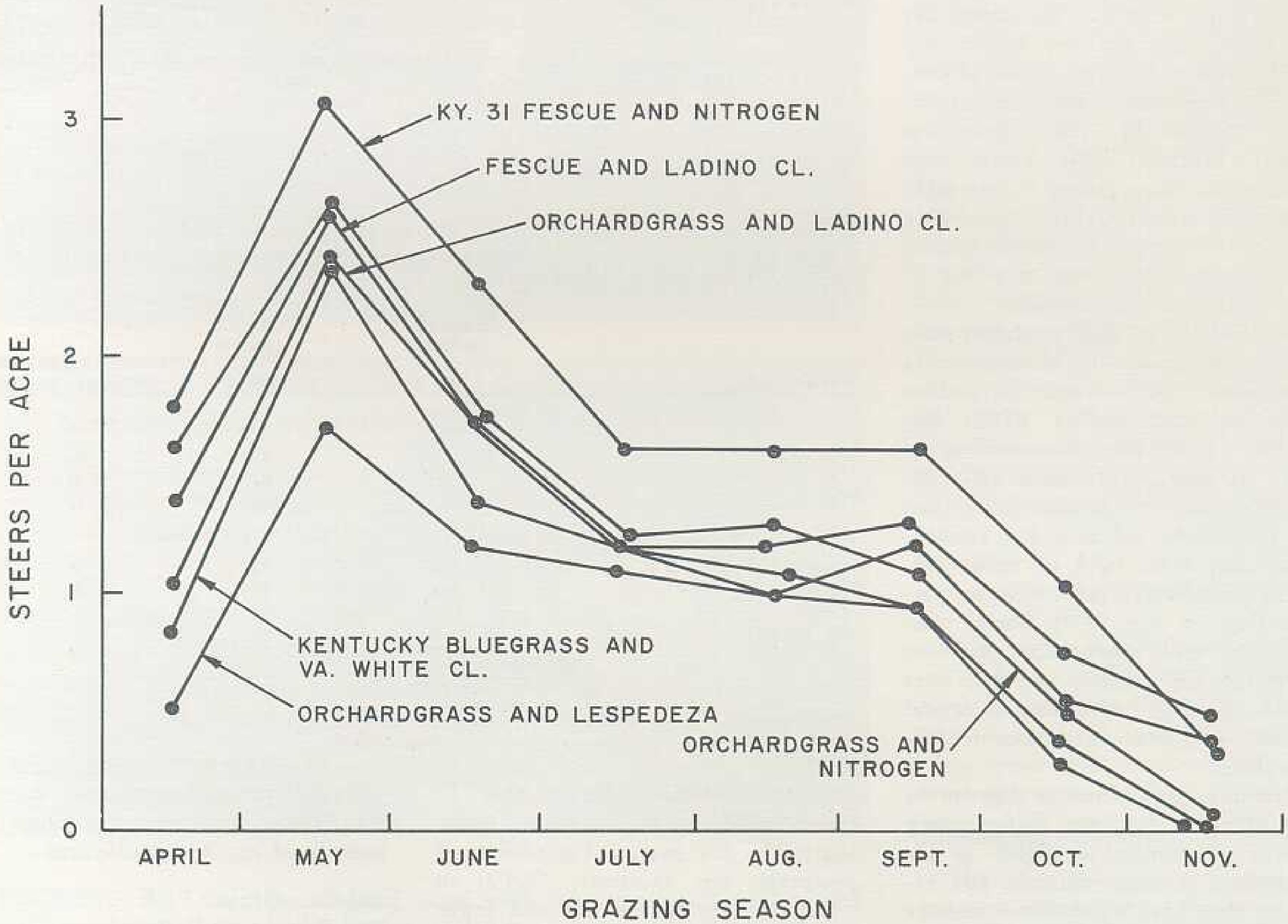


FIGURE 4. The average carrying capacity (700-lb. steers) by month for a 5-year period, 1951-1955 for different pastures at Middleburg.

by feeding concentrates at the end of the grazing seasons. Similar amounts of grain were required, but the steers that had not been fed grain on pastures needed longer feeding periods for fattening.

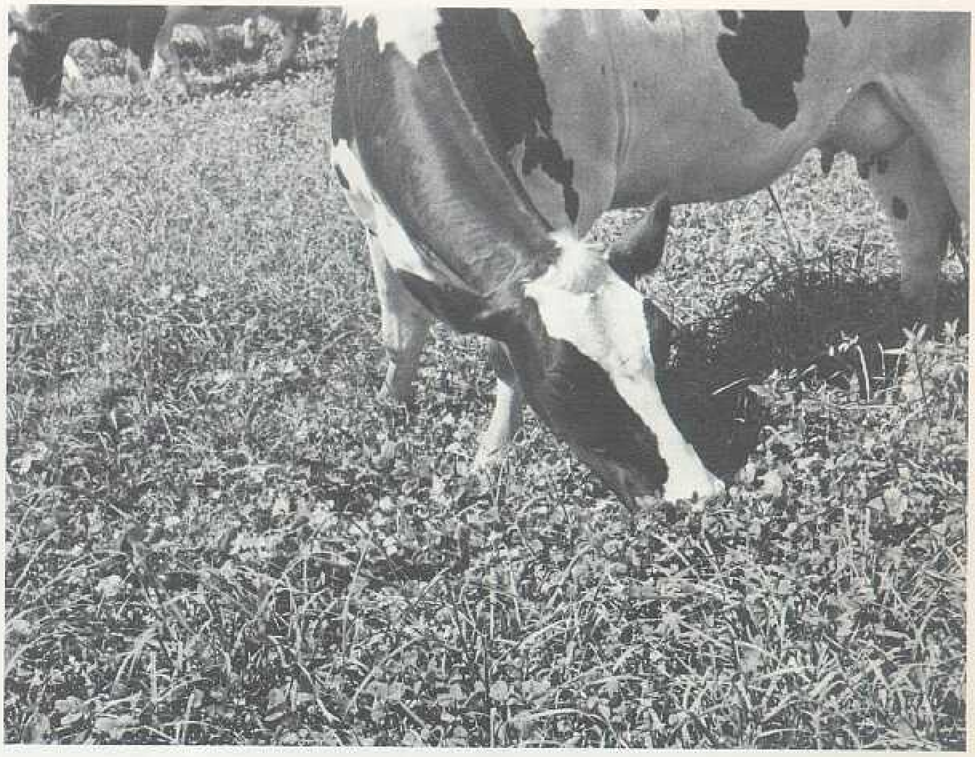
Milk Production with Protein or Energy Supplements: The cows were all fed alike on a 20% protein supplement for several weeks. Paired cows similar in milk production were then randomized to: (a) pasture with the 20% protein supplement and (b) pasture with ground shelled corn. The cows grazed together—rotationally among several pastures (bluegrass-white clover, orchardgrass-ladino clover, alfalfa-orchardgrass, and occasionally millet or sudangrass).

During three years, milk production with ground shelled corn was consistently as good as from a 20% protein supplement (Table 6). The weekly persistences in milk production for grain and protein supplements were excellent and similar. It is fortunate that ruminants convert high protein feeds to energy; otherwise, milk production might have been reduced by the 20% protein feed.

Milk Production with Rates of Supplements: Cows similar in milk production were randomized to excellent ladino clover-grass pastures. Supplements were fed at three rates: (a) none, (b) low—1 : 9, and (c) medium —1 : 4.5 (1 lb. supplement to 4.5 of milk). The supplements were a 12% protein-grain mixture in 1952, ground ear corn in 1953, and ground shelled corn in 1954.

Daily milk production (not corrected for fat) during the 3-year period averaged 35.0 lbs. for cows on pasture without supplemental feeding (Table 7). Feeding low and medium rates of supplements increased milk production by 10 and 20 percent, respectively. During the spring months, the cows refused some of the concentrates; thus, the consumption was lower than the amounts offered.

Liveweight maintenance and gains were improved as rates of supplements increased. Cows without grain supplements tended to lose weight during the first half of the grazing season. Improved milk production and bodyweights with grain feeding suggest that pastures were low in energy rather than in protein.



EXCELLENT PASTURE: Here, milk cows graze orchardgrass-ladino clover pastures at Middleburg. Cows on such high-protein pastures need only energy (grain) supplements for high milk production.

Stocking Rates Improve Efficiency of Production

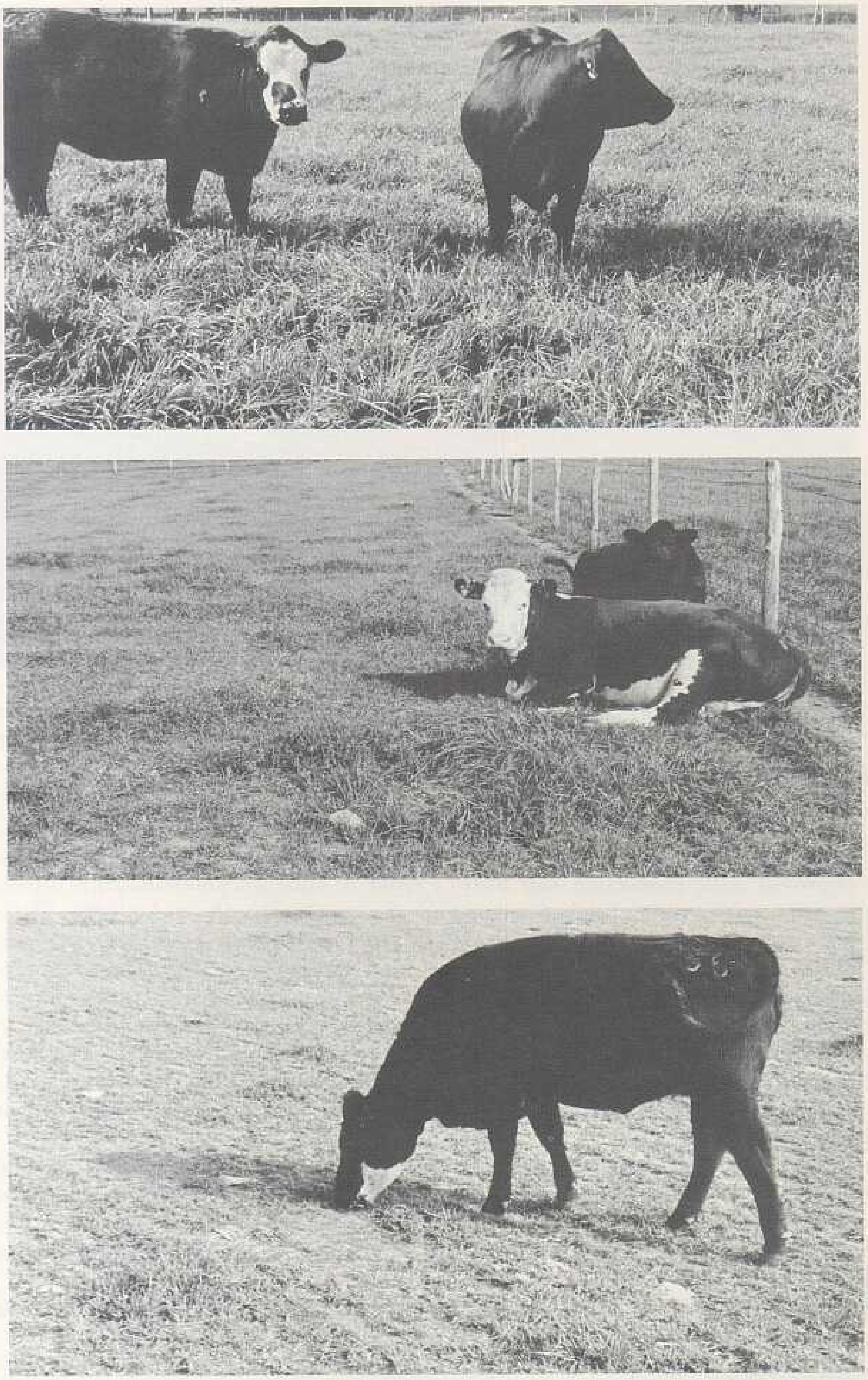
Light stocking causes high production of meat or milk per animal but low yields of animal products per acre because pasturage is wasted (not converted to animal products). Very heavy stocking depresses production per animal; hence, the yield of animal products per acre are lowered. Maximum yield per acre and per head cannot be obtained simultaneously. Stocking rates should make wise compromises between production per animal and per acre. At a medium stocking rate, where there is good pasture utilization and some depression in animal gain, acre yields of animal products will be high. The two following experiments illustrate these principles.

Experiment 1: Stocking rates on bluegrass pasture averaged 1.4 steers per acre for medium and 3.0 steers for heavy stocking. Stocking rates

TABLE 6. Milk (4% fat) produced daily when cows on good pasture were fed ground shelled corn or a 20% protein supplement.

Feed Supplements*	1955	1956	1957	Average	Weekly Persistency
Ground shelled corn	29.4 lb.	35.8 lb.	28.6 lb.	31.3 lb.	97.3%
Grain mix 20% protein	28.8 lb.	34.3 lb.	27.7 lb.	30.3 lb.	98.1%

*The supplements for the three years, lb. supplement:lbs. milk daily were: 1955 - 1 : 8, 1956 - 1 : 4, and 1957 - 1 : 6 lbs. The 20% protein supplement was a mixture of ground shelled corn and cottonseed meal.



STOCKING RATES: The stocking rates with nitrogen-fertilized orchardgrass were: (a) medium, (b) heavy, and (c) very heavy; all grazed continuously and rotationally. Cattle gr aze selectively when there is excess herbage or with light stocking.

were adjusted to the growth of pastures during the season. The average yield of the sod residue was 1235 lbs. with heavy stocking and 2224 lb. (dry matter) per acre with medium stocking (Figure 7). The daily liveweight gains per steer averaged 1.77 lb. for medium and only 0.92 lb. for heavy stocking. Liveweight gains per acre were 432 lb. for heavy and 380 lbs. for medium stocking.

There was an average of 1590 lbs. of pasture per steer with medium and only 410 lbs. with heavy stocking. However, much of this pasturage was not available for grazing as the soil was shaved of all vegetation. With medium stocking and more pasture, the steers grazed selectively consuming more and better quality pasture than for heavy stocking (Figure 7). The high liveweight gains per acre with heavy stocking are attributed to high carrying capacity and little wasted pasturage. Actually, little pasture was wasted with medium stocking.

Experiment 2: At Blacksburg and Glade Spring, bluegrass-white clover pastures were stocked with heifers at light, medium, and heavy rates. After 90 days of the flush spring growth, all three stocking rates were reduced 50% (Figure 8). The liveweight gains per heifer decreased with stocking rate, being 1.56 lb. daily with light and 1.12 lbs. heavy stocking. However, gains per heifer were reduced only 7%; but the acre gains were increased by 23% with medium as compared to heavy stocking (Figure 8).

With light stocking, the pastures were weedy, much of the pasturage grew to maturity, and was wasted. The medium and heavy stocked pastures were grazed evenly and had much white clover.

Continuous or Rotational Grazing

The ideal grazing method should produce high yields of quality pasturage for many years, a desirable grass-legume balance and weed control. Large, erect, perennial plants,

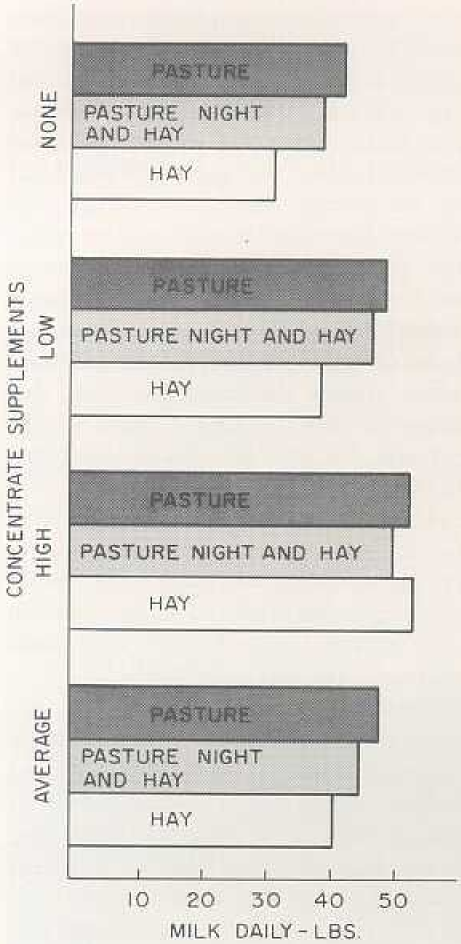


FIGURE 5. Milk production (4% fat) daily per cow during 1961 and 1962 when cows had: (a) good pasture, (b) good alfalfa hay, and (c) hay during the day and pasture at night. The cows for each of these treatments were fed at three rates of a 14% crude protein supplement: none, low (1 lb. per 8 of milk) and high (1 lb. per 3 of milk).

as alfalfa, must be grazed rotationally where short grazing is followed by long rest periods. For short or prostrate plants, as with bluegrass-white clover pastures, there is little advantage of grazing rotationally.

Meat or milk production per head depends strongly on stocking rate and degree of selective grazing. If stocking rates are similar, the production per head for continuous and rotational grazing will be similar. In actual practice, production per head is usually favored by continuous grazing, as it is necessary to accumulate reserve pasture that allows selective grazing. On the other hand, good utilization is enforced with rotational grazing. Thus, selective grazing is usually higher for continuous than for rotational grazing, especially during the spring flush growth. However, later in the season under continuous grazing, the spotted over-and under-grazing restricts gains; cattle refuse the mature growth and cannot consume enough of the short pasture. Thus, steers usually gain more with continuous than with rotational grazing during spring, but this situation is reversed later. If selective grazing is controlled, animal performance is similar for grazing methods.

The yield from pasture plants is potentially higher from rotational than from continuous grazing. With medium to small plants, rotational may be superior to continuous grazing only with heavy stocking. Rotational grazing will not improve the bad seasonal pasture distribution. It is especially practical to use semi-continuous and rotational grazing in a 12-month forage plan to obtain more uniform feed supply (See later section).

With continuous grazing, the animals per land area are usually kept constant (set-stocked), causing either under or overstocking, as growth is not predictable. In our experiments, continuous grazing was favored, since animals were added or withdrawn to avoid pasture injury and to attain good utilization. With rotational utilization, the excess herbage is usually harvested for winter feed.

Milk Production from Three Mixtures: Three grass-legume pastures (A. alfalfa-orchardgrass, B. ladino clover-orchardgrass, and C. white clover-birdsfoot trefoil-bluegrass) were each grazed continuously and rotationally. With rotational grazing, there were 10 equal sized strips divided by electric fences. The rotational alfalfa-orchardgrass pastures were generally grazed when alfalfa was in a bud or to one-tenth bloom stage to a sod residue of about three inches, when most of the leafy growth had been consumed. Grazing a pasture three to four days allowed 27 to 36 days recovery. The rotational ladino clover-grass pastures were generally grazed from a height of six to twelve inches to about a two inch sod residue. The white clover-trefoil-bluegrass rotational pastures were grazed from a four to seven inch height to about three fourths inch. The desired stages of growth and good utilization for the pastures with both rotational and continuous grazing were maintained by adjusting stocking with other cows. Grain supplements were excluded to obtain better evaluations of pastures for milk production; this along with advanced lactation during one year, caused the low daily milk yields per cow.

Milk Produced Daily per Cow and Per Acre: Daily milk yields per cow, during two years for the three legume-grass mixtures, averaged 26.6 pounds, for continuous and 25.8 pounds for rotational grazing (Table 8). Likewise, milk production per cow for rotational and continuous grazing was similar for each of the three legume-grass mixtures. All pastures were

FIGURE 6. Feeding light rates (1% of bodyweight) of shelled corn after mid-June increased liveweight gains over steers having only pasture. The fat conditions of weanlings caused lower gains than for the long yearlings.

stocked to attain similar good herbage utilization, and similar selective grazing and stocking rate for the two grazing methods and the three mixtures.

There was 25 percent more milk per acre with rotational than with continuous grazing, when averaging all pastures (Table 8). With alfalfa-orchardgrass and the white clover-trefoil pastures, there was 37 to 40 percent more milk per acre with rotational than with continuous grazing. The rotationally grazed pastures had feed for more cows; hence, more milk than for the continuously grazed pastures. There was feed for 27 percent more cows with rotational than with continuous grazing (all pastures averaged). The alfalfa-orchardgrass pastures produced feed to graze 43 percent more cows with rotational than with continuous grazing; with the white clover-trefoil pastures, there was a 27 percent yield increase with rotational grazing.

The yield potential of the ladino clover-orchardgrass pastures was low because of very poor stands of clover. Production was somewhat less with rotational than with continuous grazing. Pastures low in production do not usually respond to intensive (rotational) grazing.

Plant Stands: With rotational grazing alfalfa stayed productive, making up 48 percent of the pasturage as compared to only 17 percent with continuous grazing during the second season. By the end of the second season, the vigor of alfalfa stands on continuously grazed pastures was very poor; weed encroachment was severe, three times as many weeds with continuous as for rotational grazing.

Birdsfoot trefoil in the white clover-bluegrass pastures made up 12 percent of the pasture with rotational and 0.5 percent with continuous grazing. On the other hand, there was about 50 percent more white clover with continuous than with rotational grazing management.

Milk Production with Rotational and Alternate Grazing: Orchardgrass-ladino clover pastures were grazed two ways: a) 10 lots rotationally and b) two lots grazed alternately. The cows in the 10-lot plan were stocked to consume the growth on a fresh pasture in two to three days, allowing 18-27 days recovery. A fresh pasture was generally grazed in two days during spring as pastures recovered in about 18 days. Cows were moved into a fresh pasture when the growth was eight to twelve inches high and removed when the growth was grazed to an average height of about 2½ inches. For two-lot alternate grazing, the cows grazed a pasture for two to three weeks during spring when growth recovery was rapid and for four to seven weeks during summer when growth recovery was slow. Because of long grazing periods within pastures, the two-lot plan is considered similar to continuous grazing. The cows in each of the four pastures were fed at three rates of grain concentrates (none, medium, and high). The milk production data are averages for all concentrate rates. Results with concentrates are given in Table 7.

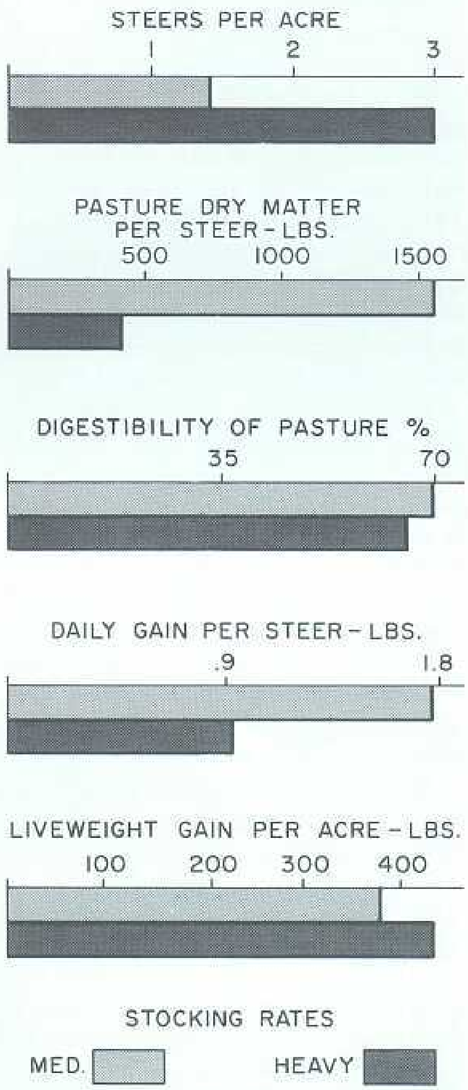


FIGURE 7. Increased stocking rates (steers per acre) reduced the available pasturage, its digestibility, and daily liveweight gains per steer. Liveweight gains per acre were highest for heavy stocking. The data are for bluegrass-white clover pastures grazed continuously during 1961. Stocking rates based on 700 lb. yearlings.

Quality as Shown by Milk Production per Cow: The 10-lot rotationally grazed pastures looked attractive and well managed. The grass-clover balance was excellent and there was more uniform grazing with the 10-lot than with the two-lot alternate grazing. Basing prediction on appearance, one would have expected more milk production from rotational than from alternate grazing. However, milk produced per cow averaged for a 3-year period was similar, 38.0 for alternate and 39.4 for rotational grazing (Table 9). During spring, the cows grazing the alternate pastures gave more milk than those grazing rotationally (Figure 9). This is attributed to more selective grazing with alternate than with rotational grazing especially during spring flush growth. However, after mid-season, the rotational cows produced more milk than those grazing alternately (semi-continuously). During late season, the alternately grazed pastures had closely grazed areas of young grass, but the stemmy old growths were not grazed readily. Rotational grazing enforced better utilization and controlled the stage of growth.

Yield and Milk per Acre: The yield of pastures, as shown by cow days grazing per acre year, was 20 percent more for the rotational than for alternate grazing. Since milk production did not differ per cow, there was also 20 percent more milk per acre for rotational than alternate grazing. The 18 to 27 days for pasture recovery between grazings stimulated dry matter production and maintained good stands of orchardgrass and ladino clover. The prolonged grazing periods on alternate lots caused extreme over- and undergrazing; the overgrazed areas made slow regrowth, especially during the latter part of the season. With two-lot alternate grazing, there was a shortage of pasture in late season and grazing had to be terminated earlier with alternate than with rotational grazing.

Clover Pasture Improves Milk Production: Ladino clover (no grass) was grazed rotationally during one year and may be compared with the ladino clover-orchardgrass pastures. More milk was produced from cows grazing ladino clover than for orchardgrass-ladino clover (Figure 9). The clover pastures were not grazed the second year because of severe weediness and poor clover stands. Weeds and loss of clover stands were not a problem in the pastures with orchardgrass.

Liveweight Gains with Orchardgrass: Orchardgrass, fertilized with 200 pounds N per acre in several split applications, was grazed continuously and rotationally at three stocking rates with yearling steers. There was some adjustment of number of steers per acre to maintain very low to medium supplies of pasture per steer for the three stocking rates.

When all stocking rates were averaged the liveweight gains per acre and per steer for rotational and continuous grazing were similar (Table 10). With very heavy stocking, the acre liveweight gains were 29 percent more for rotational than for continuous grazing. There was a trend for steers to gain more with continuous than for rotational grazing with medium and heavy stocking; this relationship was reversed with very heavy stocking.

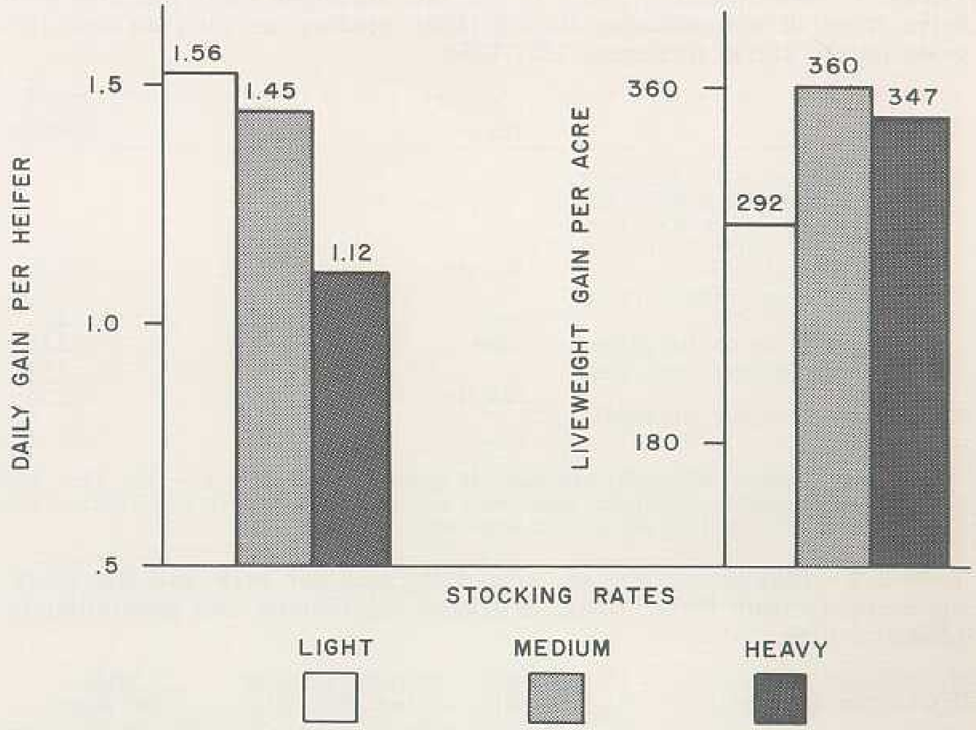


FIGURE 8. The liveweight gains per heifer and per acre with three rates of stocking: light, 1.33; medium, 2; and heavy, 2.33 heifers per acre on continuously grazed bluegrass pasture in 1967. The stocking rates were reduced 50% in July. This is a cooperative experiment with TVA at Blacksburg and Glade Spring.

Stocking rates caused big differences in liveweight gains per acre and per head (Table 10). When continuous and rotational grazing were averaged the gains per steer for stocking rates were: medium, 1.56 pounds; heavy, 1.30 pounds; and 0.95 pounds for very heavy stocking. Liveweight gains averaged 432 pounds per acre for medium stocking, 394 pounds for heavy, and 303 pounds for very heavy stocking.

During several years in the five-year period, grazing was discontinued soon after mid-season as there was little growth because of severe droughts. This favored pasture survival for the heavier stocking rates and possibly eliminated differences caused by grazing methods. Each of the 4 or 5 small lots for rotational grazing had water and salt; thus, about as much area was sod bare in each rotational lot as in one continuously grazed pasture.

Rotational Grazing For High Animal Production

When two groups of cattle are used in rotational grazing, the first grazers produce more per head than the clean-up last grazers because of higher nutrition of pasturage they ate. In practice, the last grazers should be low producers or animals that do not require high nutrition.

Nutritional Changes During Grazing: These principles apply to milk and meat production; but because of sensitivity to nutrition, milk flow data are used as an example. As cattle graze a fresh rotation pasture, there are cyclic changes in milk production explained in Figure 10. Milk production increases sharply after cows graze a

TABLE 7. Milk (not corrected to 4% fat) produced daily per cow with three rates of concentrates during three grazing seasons on orchard-grass-ladino clover pastures, 1952-1954.

	Milk per cow at three rates concentrates		
	None	Low	Medium
1. Milk produced daily during a pregrazing standardization period of 2 to 3 weeks when concentrates were fed at the rate of 1 lb. to 4 of milk	40.7 lb.	42.0 lb.	42.9 lb.
2. Rates of concentrates—lb.:lb. of milk*	none	1 : 9	1 : 45
Rates based on consumption	none	1 : 93	1 : 5.1
3. Milk produced per cow—average	35.0 lb.	38.5 lb.	42.2 lb.
4. Percent of original (standardization)	85%	91%	92%

*The grazing seasons were 187, 133, and 118 dayys, respectively, for 1952, 1953, and 1954. The concentrate feeds for each rate are based (milk per cow) during the pregrazing standardization period and were kept constant.

TABLE 8. Milk produced per cow daily and per acre and the carrying capacity from three mixtures grazed rotationally and continuously, 1958 and 1959.

Mixture and Grazing Management	Milk per cow daily	Carrying Capacity Cows Per Acre		Milk Per Acre	
	Lbs.	Days	Increase	Lbs.	% Increase
Alfalfa-orchardgrass					
Continuous	27.1	150		3726	
Rotational	28.4	216	43%	5233	40%
Ladino clover-orchardgrass					
Continuous	27.4	144		3288	
Rotational	23.3	149	10%	3265	0
White clover-bluegrass-birdsfoot trefoil					
Continuous	25.4	147		3077	
Rotational	25.6	187	27%	4204	37%
Average					
Continuous	26.6	147		3364	
Rotational	25.8	187	27%	4234	25%

TABLE 9. Milk (not 4% fat corrected) production per cow and cow days grazing per acre with rotational and alternate two grazing during 1952-55.[1]

	Grazing Methods	
	A. 10-pasture lots grazed rotationally	B. 2 pastures grazed alternately (semi-continuous grazing)
1. Milk production—daily per cow		
a. During early lactation before starting the grazing (standardization period)	43.0 lb.	41.8 lb.
b. Milk produced during the grazing season	39.4 lb.	38.0 lb.
c. Persistency of milk production, percent standardization	91.6%	90.9%
2. Cow-days pasturage during the grazing season	150 days	125 days

[1]The carrying capacity data are based or two years as accurate records unfortunately were not kept during the first and best grazing season.

fresh pasture and later as pasturage declines milk flow declines sharply. At first with much pasturage, cattle select the best quality and also consume more; hence, production increased rapidly and stayed high for several days. Near the end of grazing a rotational pasture, milk per cow drops not only because of lower consumption but also because of lower energy and protein in the eaten pasturage. These sharp declines of milk caused by low nutrition lag into fresh pastures, where they are soon elevated by excellent nutrition (Figure 11).

In reality, cattle encounter sharp changes in relative stocking rates, while consuming the pasturage in a rotationally grazed pasture. At first, the large supply of feed in a fresh pasture amounts to light stocking; finally as the feed becomes limited, stocking becomes relatively heavier. Short grazing periods of one or two days will make for more even nutrition but not improved milk or meat production per head, since low and high nutrition of pasture cancel each other.

Liveweight Gains with Two Methods of Rotational Grazing: Two methods of handling steers under rotational grazing were: (a) ordinary rotational grazing where one group of steers grazed a sequence of pastures and (b) rotational grazing with two groups of steers, first and last grazers. The first grazers were shifted to a fresh pasture when about half of the pasturage had been consumed; last grazers consumed the residues behind the first grazers.

Experiment 1: Several species and mixtures were grazed simultaneously as mentioned above (Table 11). With ordinary rotational grazing for all pastures, the steers gained 1.13 lbs. daily; but the first grazers gained 1.33 lb. and the last grazers only 0.89 lb. The gains of the first grazers were highest with orchardgrass-clover and lowest for fescue alone; but for a given pasture, the first grazers consistently gained the most and the last grazers the least (Table 11).

Rate of steer gain is associated with amounts of available herbage and selective grazing. When steers were turned into a freshly grazed pasture (ordinary rotational grazing), there were 840 pounds of pasturage, and when withdrawn there were 140 pounds per acre (Table 11). The digestibility of the eaten parsurage was high as steers grazed a fresh pasture and declined rapidly as pasture was eaten (Figure 11). Thus, animals with surplus pasture selected plant parts that were high in energy.

The pasturage per acre averaged 866 pounds of dry matter per acre when the first grazers were moved to a fresh pasture and 461 pounds when they were removed (Table 11). There were 461 pounds of pasture when the last grazers entered and 136 pounds of residue when they were removed. This suggests that the first grazers consumed 24 percent more pasturage than the last grazers. The first grazers gained the most because of high consumption and selection of the more digestible pasturage.

Experiment 2: During 1959 and 1960, a series of pasture mixtures (bluegrass-white clover, orchardgrass-ladino clover, and orchardgrass-alfalfa) was grazed rotationally with one and two groups of steers at similar stocking rates. The gains of the first grazers averaged 1.35 pounds; 67 percent more than the last grazers and 26 percent more than the steers on ordinary rotational grazing (Table 12). The total liveweight gains per acre for ordinary rotational grazing were 371 lbs. and 382 pounds for the

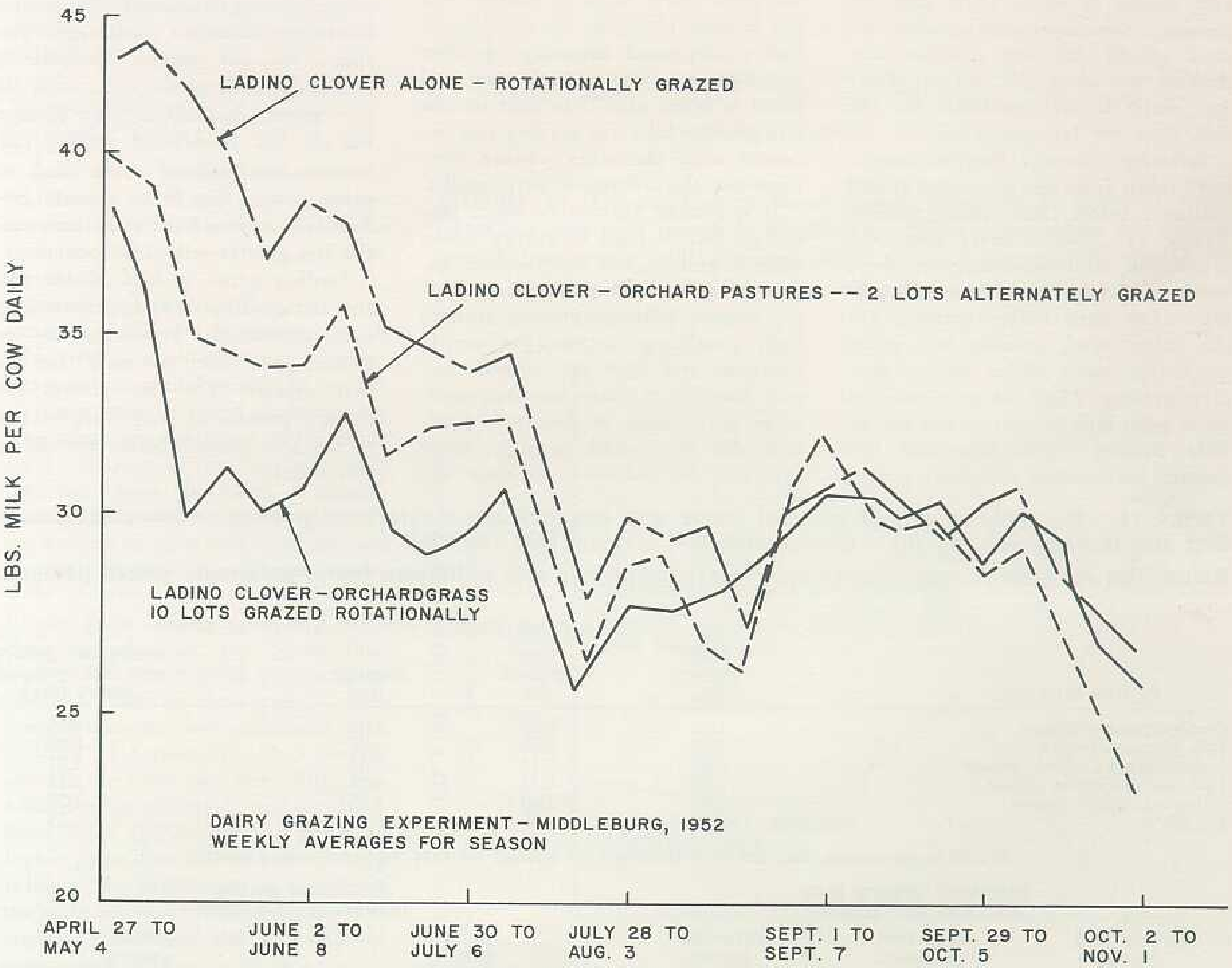


FIGURE 9. The milk production on different pastures based on an average of cows on three rates of grain feeding.

TABLE 10. Steer gains (daily and per acre) and steer days per acre when orchardgrass is grazed rotationally and continuously at three stocking rates during five years.

	Stocking Rates			
	Medium	Heavy	Very Heavy	Average
		Rotational Grazing		
Daily gain per steer, lb.	1.47	1.21	1.02	1.23
Number steer days per acre	297	342	351	330
Total gain per acre, lb.	428	395	341	388
		Continuous Grazing		
Daily gain per steer, lb.	1.64	1.39	0.88	1.30
Number steer days per acre	276	296	327	300
Total gain per acre, lb.	435	392	265	364

Stocking rates were obtained by reducing the size of pastures as stocking increased and also by some adjusting of steers per area.

two groups of steers (first and last grazers). Rotational grazing with two steer groups does not increase production per acre; the system allows for much higher nutrition for the first than the last grazers.

Selective Grazing: Pasture samples were taken from the rotational grazed pastures before and after grazing (Table 13). For ordinary rotational grazing of alfalfa-orchardgrass, there were nine percentage units more crude fiber after than before grazing. On the other hand, protein was seven percentage units higher before than after grazing. Thus, the steers selected plant parts high in protein and low in fiber content. With first and last grazers, both groups selectively grazed for plant parts high in protein and low in fiber. However, the first grazers had a nutritional advantage as their pasturage was higher in protein and lower in crude fiber than that for the last grazers. Selective grazing also occurred with the other pasture mixtures but the differences were smaller.

It is evident that cattle select pasturage that is high in energy value, high in protein, and low in fiber. Intake also decreases as pasturage supply lessens. Selective grazing as with light stocking encourages ample nutrition and high per animal output; however, it causes less than maximum acre yields of livestock products due to wasted herbage. These principles of selective grazing and consequent changes in animal nutrition apply to continuous or other grazing practices.

Milk per Cow with First and Last Grazers: Cows in early lactation were used to measure milk production when one group grazed first and a second group of cows grazed the remaining half of the pasturage in a rotational system. During the first 49 days on excellent orchardgrass-clover pastures and no grain feeding, the milk production per cow increased 4 percent with first grazers and declined 28 percent with last grazers (Table 14). After grazing rotationally for another 70 days on excellent alfalfa-grass pastures, the last grazers declined 48 percent in milk production, while the first grazers declined only 21 percent. For the last 14 days of grazing (advanced lactation of cows and no grain fed), the first grazers produced 27.6 pounds of milk daily and the last grazers only 14.2 pounds.

Feeding grain to half of the first and last grazing cows improved daily milk production. However, the last grazers gave much less milk than the first grazers. The last grazers had enough pasture as they were rotated to the next pasture before the residue was scarce.

TABLE 11. The daily liveweight gains of steers with two methods of rotational grazing: (a) two steer groups, first and last grazers and (b) ordinary rotational grazing, 1958 and 1959.

Below: The available pasturage when steers were introduced and withdrawn from rotationally grazed pastures.

	Rotational grazing with two groups of steers			
Pasture Mixtures	First grazers lbs.	Last grazers lbs.	Average lbs.	Rotational grazing with one group of steers (lbs.)
Orchardgrass-nitrogen	1.23	0.80	1.02	0.96
Tall fescue-nitrogen	1.09	0.75	.92	0.89
Orchardgrass-Ladino clover	1.53	1.14	1.34	1.31
Tall fescue-Ladino clover	1.31	0.77	1.04	1.18
Bluegrass-white clover	1.49	1.00	1.25	1.29
AVERAGE	1.33	0.89	1.11	1.13

Available pasturage, lbs. per acre (Average for season for first four mixtures above)

Rotational grazing with first and last grazers			Rotational grazing one group of animals	
Before first grazers	After first grazers*	After last grazers	Before grazing	After grazing
866	461	136	840	140

*Identical with before last grazers

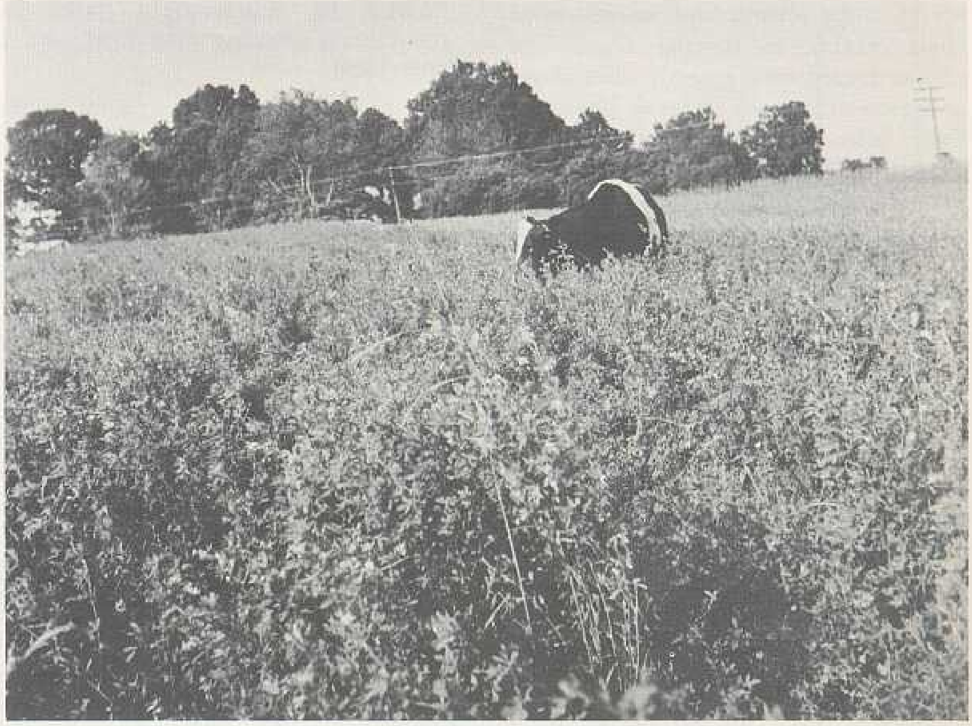
Animals Injure Pastures

Pastures furnish good quality feed for horses, cattle, and sheep, so it is often said that animals and pastures are mutually beneficial. Grazing animals, however, are both harmful and beneficial to the pasture-soil complex. Animal excreta improve soil fertility, the added nitrogen improving growth of grassy components in sods. However, the benefits from animal excreta are often nullified because of uneven return, depositions in off-pasture shady areas, and inefficient utilization because of large urine and fecal deposits and lethal effects of large deposits. Return of excreta is more uniform with small than with large animals.

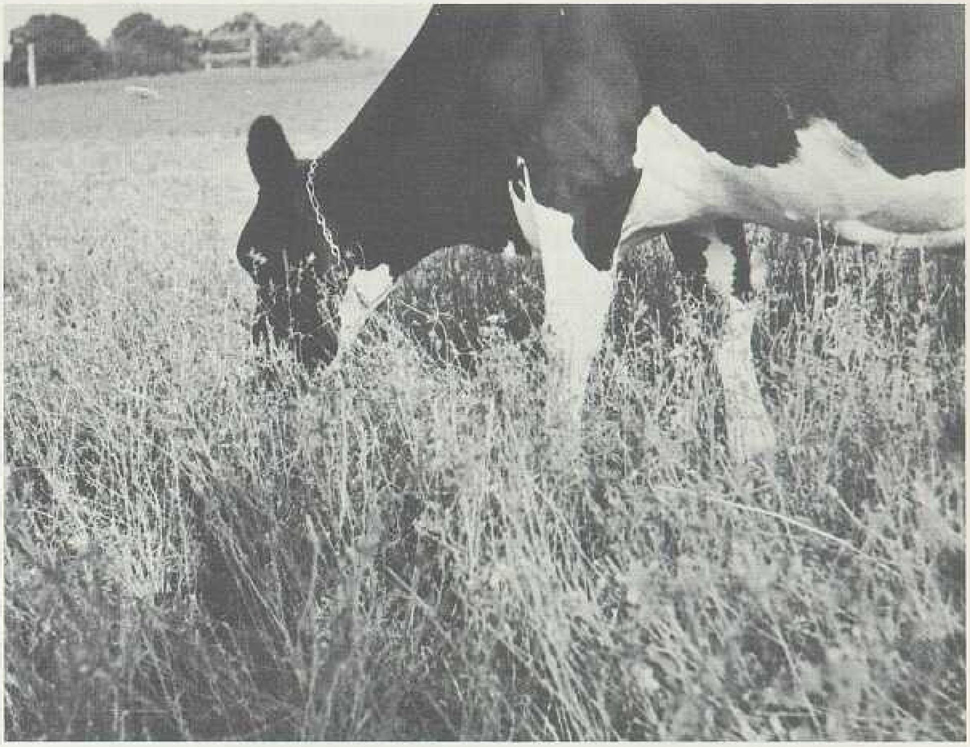
Several experiments were done to compare yields when cutting and grazing the sod. Small plots of orchardgrass were mowed whenever the grass was five and eleven inches high to each of ¾ and 2½ inch sod residues for three grazing seasons. Fenced areas were simultaneously grazed to similar sod residues with calm cows by early morning and late afternoon grazing. This one-day grazing for all seasonal regrowths occurred on the same day that the ungrazed plots were mowed. Small strips were harvested for yields before each grazing. All feces were removed, and all plots were fertilized liberally with nitrogen.

The dry matter yields of plots grazed for a three-year period were 4,398 pounds, 43 percent less than those of the mowed plots (Figure 12). After a winter rest, all plots were mowed for yields the next year. The yields were similar; hence, grazing did not have a carryover harmful effect. The yields during 1958 were much higher than for the previous three years because the first growth was cut in a headed stage and the regrowths were also taller than for previous years. Other experiments also show slower regrowth with grazing than with mowing, when the effects from animal excreta are not considered.

The low yields under grazing are apparently attributable to the pulling



SPECIAL GRAZING FOR HIGH PRODUCTION: Above, the cows which had first access to the pastures and were removed to fresh pastures when about half of the growth was eaten gave much more milk than the last grazers, below. The last grazers had plenty of pasture, but it was lower in protein, digestibility and less was eaten. The mixture is an alfalfa-orchardgrass mixture.



up of some shoots and uncontrolled close grazing in spotted areas. The closely grazed areas possibly show slower regrowth because of fewer leaves for light interception. Moreover, closely grazed stubble has less of the carbohydrates that stimuate regrowth. Basal and soil temperature increases, due to less sod insulation in closely grazed areas, retard regrowth. Another experiment at Middleburg shows that large grazing animals compact the near-surface soil. This could inhibit root development and water infiltration. The damaging effects from grazing animals on orchardgrass sod disappeared when the sod was rested during the winter months.

Grazing during the winter when soils are wet and alternately freezing and thawing can cause severe compaction and injury to pastures. For best management, cattle should be restricted to small areas during winter to favor good soil and sod management for most of the pastures.

Practical Management With a 12-Months Forage Plan

The Problem: Pastures should be grazed to get high yields of animal products per acre. At the same time, grazing should be controlled to maintain quality and availability for suitable production per animal. The flush pasture growth in spring with low summer and autumn yields do not fulfill the seasonal needs of cattle (Figure 13). With beef cattle, calves and steers need more feed as they increase in size during the pasture season. With late summer freshening of dairy cows, feed needs are highest when pasture production is lowest.

Because of peaks and dips in pasture production, there is not a practical stocking rate when the pasture land area and number of cattle are constant; there will be either a shortage or a wasted pasture. Rotational grazing does not improve the seasonal distribution of pastures very much.

Good utilization and reasonable assurance of enough pasture for a long grazing season may be obtained in two ways: (1) by reducing the stocking rates by 50 percent after July (this could be done by selling steers to feeder sales) or (2) by using a 12-month forage plan.

Plans for 12-Month Forage: This is a planned program for constant or varying numbers of cattle. During spring, the pasture area is restricted to the cattle needs. Ungrazed accumulated pasture is cut for hay or silage in spring and then grazed for the rest of the year.

With a simple 12-month forage plan at Middleburg, herds are restricted to fields furnishing enough spring grazing. The ungrazed bluegrass pastures harvested for hay in late spring are grazed after haying; thus, about twice as much acreage providing enough pasture in summer is made available. The hay has been very satisfactory for herd maintenance during winter. In another trial, a combination of continuous and rotational grazing with harvesting was easy to handle. During early April, when pasture growth was slow, all fescue pastures were grazed continuously with milk cows. Later as growth was progressively faster

TABLE 12. Liveweight gains per acre and per steer with ordinary rotational grazing and first and last grazers in rotational grazing, 1959 and 1960.

	Kind of Rotational Grazing			
	First grazers	Last grazers	Average or Total	Ordinary-One group of steers
	Daily liveweight gain/steer			
1959	1.21	0.73	0.97	0.99
1960	1.48	0.89	1.19	1.14
Avg.	1.35	0.81	1.08	1.07
	Steers per acre			
1959	1.05	1.05	2.10	2.08
1960	1.02	1.02	2.04	1.89
Avg.	1.03	1.03	2.07	1.99
	Liveweight gains per acre, total			
1959	198	117	315	329
1960	278	170	448	413
Avg.	238	144	382	371

TABLE 13. Three pasture mixtures grazed with ordinary rotational grazing (one animal group) and rotational grazing with first and last grazers show selection of low fiber and high protein pasturage, 1959.

	Pasture Mixtures		
Rotational Grazing Methods	Alfalfa-Orchard.	White Cl.-Bluegrass	Ladino Cl.-Orchard.
A. Two animal groups	Crude fiber increases in ungrazed residue as pastures are grazed.		
Before first grazers	25%	24%	25%
Before last grazers*	30%	25%	26%
After last grazers	36%	25%	28%
B. One animal group			
Before grazing	25%	23%	25%
After grazing	34%	26%	28%
A. Two animal groups	Protein declines as pastures are grazed.		
Before first grazers	22%	20%	19%
Before last grazers*	16%	18%	17%
After last grazers	13%	17%	14%
B. One animal group			
Before grazing	21%	19%	19%
After grazing	14%	16%	14%

*Also same as after first grazers

pleted soil fertility, pests, or other causes is universal.

Ideally, a 12-month forage program should be planned for each farm; the production potential of soils, feed needs of livestock, facilities, and the farmer's ability should be considered. If soils are suitable for corn, it has first priority for the land. When harvested for silage, corn produces about twice as much of a high energy feed as alfalfa. Combinations of perennial sod crops, small grains, corn, and other annuals may be used for planning 12-months feed plans. Even nutrition, quality, and dependable feed supplies can be arranged for specific cattle needs with such planned feed programs.

SILAGE AND HAY FOR FEEDER AND FATTENING CATTLE

During the first 10-year period at Middleburg, almost all of the feedlot experiments with cattle were planned to produce meat efficiently with silage and hay from perennial sod crops. This was done because the rolling to steep topography for much of Virginia's open land makes sod crops a necessity to control soil erosion. Also, at that time, high winter bodyweight gains were not wanted as most gain was to be obtained during the relatively cheap pasture period.

As the trend to finishing cattle for slaughter at younger ages developed, less dependence was placed on sod crops because their energy content was too low to fatten cattle efficiently. Research shifted to corn silage for a cheap source of energy. It was found that yearling cattle could be fattened to a desirable grade, with the use of some silage as the main energy source. As a result, large quantities of expensive grains are no longer needed to fatten beef cattle. Silages produced from corn and alfalfa can be the major source of feed nutrients. Research at the Virginia Forage Research Station has played a major role in achieving this favorable situation.

CONTINUOUS GRAZING COMPARED WITH 12-MONTH FORAGE PLAN

Continuous grazing was compared with a 12-month forage plan in a six-year (1953-58) experiment at the Virginia Forage Research Station. The two treatments were repeated four times. Fertilization was alike for both treatments.

Continuous Grazing

One three-acre field with one mixture (bluegrass-white clover-orchardgrass) was grazed continuously. The pastures were stocked to use all the pasturage. A more leafy good quality pasturage was obtained through use of more animals in spring than in summer. The seed heads of grasses were mowed high to improve grazing.

12-Month Forage Plan

A three-acre field was divided into five fields. The area was stocked with four yearlings. The first two or three fields (.3 to .45 acres per head) were grazed rotationally during spring. The other two or three fields were harvested for winter feed in spring. As growth slowed up later in the season, more or all of the fields were grazed. Using mixtures flexibly for grazing as needed, or harvesting for winter feed, increased animal production per acre as forage was not wasted.

Field 1—Bluegrass-white clover-orchardgrass: for rotational grazing all season.

Field 2—Orchard-ladino clover-red clover: for rotational grazing all season.

Field 3—Alfalfa-orchard ladino clover: for silage, then hay, then rotational grazing or hay.

Field 4—Alfalfa-orchard-ladino clover: for silage, then hay, then rotational grazing or hay.

Field 5—Alfalfa-orchardgrass: for silage, then hay, and then hay for grazing.

than utilization, some pastures were closed. Finally, the cows grazed only one of five fields. The closed pastures from which the cattle had been removed at intervals, with different amounts of regrowth, were ideal for the sequence of rotational grazing. During fast-growth periods, the fields not needed for grazing were harvested for hay. During the slow autumn growth, the pastures were again grazed continuously.

A five-field feed plan with different grasses and legumes was stocked at a rate of one 700 pound yearling per .75 acres. Two or three of the fields, .3 to .5 acres per 700 pound yearling, furnished pasture for spring grazing. The ungrazed spring growth in the remaining fields was harvested for silage and hay as explained in box.

Areas of the same size were grazed continuously and also stocked at the rate of one yearling per 0.75 acres of pasture. However, because of so much wasted pasture during spring, cattle were added to obtain better utilization and for controlling quality and botanical composition. This caused about a 20 percent increase in production over constant stocking as used by farmers. This should be kept in mind with regard to the following results.

Amount of Feed: Grazing started in early April and ended in October or November. The 12-months feed plan furnished 188 days from grazing and enough harvested feed for 196 days, 384 days of feed per acre for a 700 pound yearling each year (Table 15). This was 72 percent more than with continuous grazing. The 12-month plan produced much more than continuous grazing each year during the six years (Figure 14).

Liveweight Gains: The daily liveweight gains for the pasture part of the 12-month plan were 1.25 pound, 10 percent lower than for continuous grazing (Table 15). Under continuous grazing, it was necessary to keep some reserve pasture because of naturally occurring droughts. Thus, the somewhat higher selective grazing with continuous grazing accounts for slightly higher gains than rotational utilization with the 12-month plan.

Liveweight gains per acre from grazing and winter feed averaged 432 pounds per acre for the 12-month plan, 41 percent more than for continuous grazing. Winter gains from the good quality hay and silage were

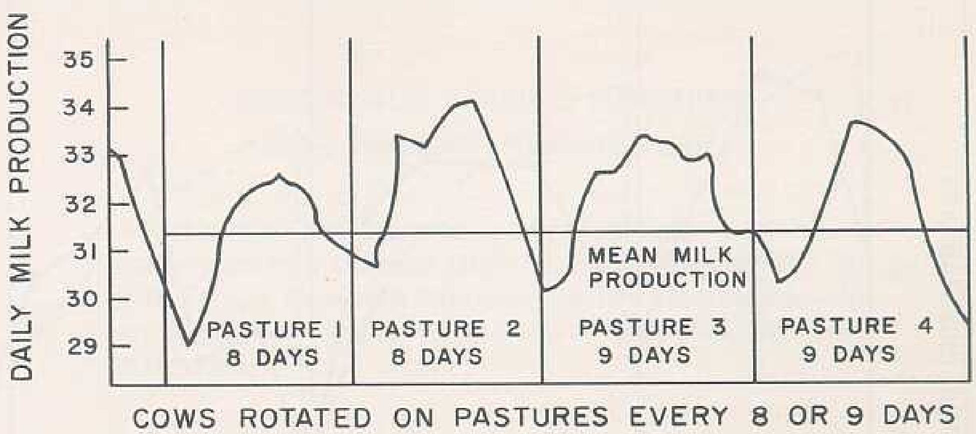


FIGURE 10. Above: Actual milk produced daily per cow (no grain supplement) while grazing 8 to 9 days in a sequence of four rotationally grazed orchardgrass-ladino clover pastures. Under normal rotational grazing where one animal group utilizes the pasturage there is, in terms of available pasturage, a shift from initial light to final heavy stocking.

TABLE 14. Rotational grazing with first and then last grazers on two mixtures: daily milk production of Holstein cows, 1957.

	Rotational Grazing			
	First Grazers		Last Grazers	
	*Grain	No Grain	*Grain	No Grain
1. Standardization period: All cows fed 16% protein feed at the rate of 1 lb/6 lb milk, for a 28-day winter feeding period before the experiment started.				
(a) 4% milk per cow daily during this period, lb.	42.6	41.2	43.0	42.2
2. The cows then grazed orchardgrass/Ladino clover pasture for 49 days.				
(a) Lb. milk daily	44.4	42.9	39.9	30.5
(b) Relative to standardization period	104.0	104.0	93.0	72.0
3. The cows then grazed alfalfa/orchardgrass mixture for 70 days				
(a) Lb. milk daily	39.7	32.4	33.8	21.8
(b) Relative to standardization period	93.0	79.0	79.0	52.0
(c) Lb. milk daily for the last 14 days	34.4	27.6	25.0	14.2
(d) Relative to standardization period	81.0	67.0	58.0	36.0

*Ground shelled corn was fed at the rate of 5 lb. daily per cow for the season.

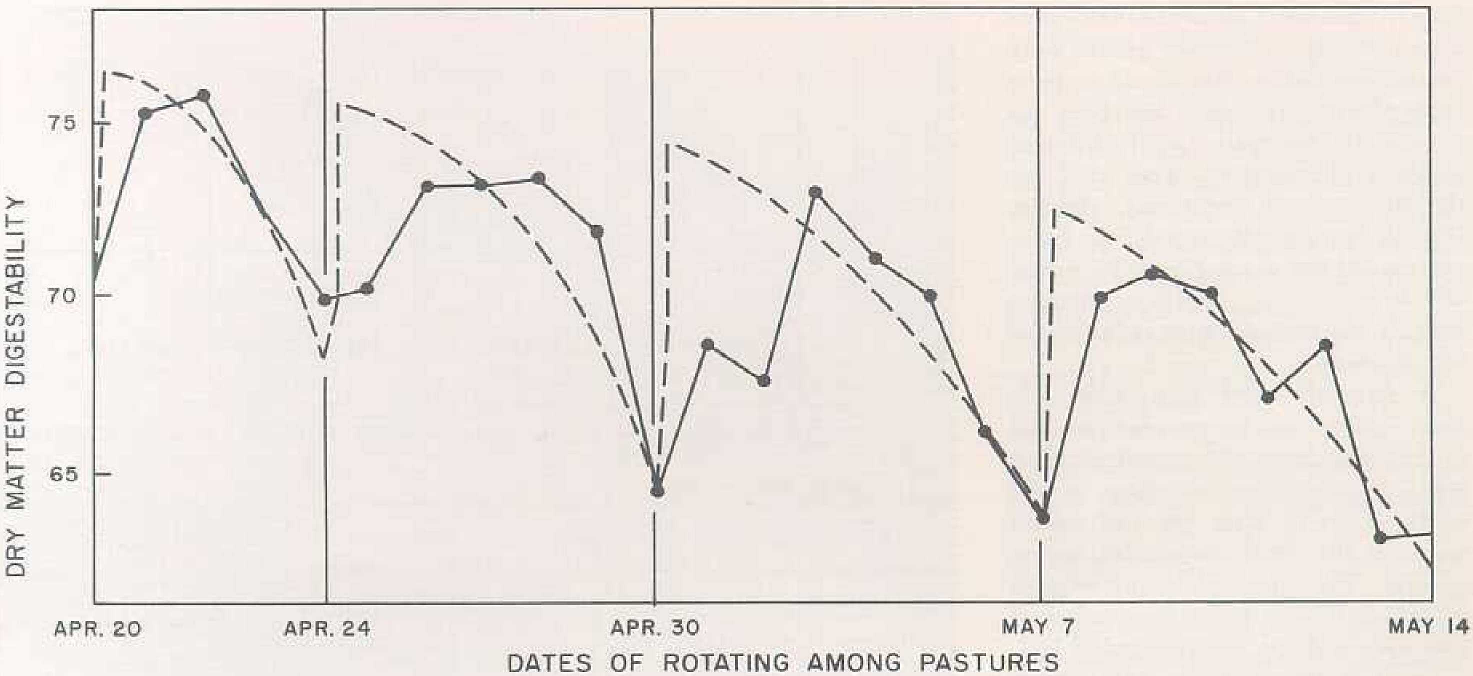


FIGURE 11. The dry matter digestibility of ingested orchardgrass pasturage under rotational grazing of nitrogen fertilized orchardgrass pastures, 1959. High dry matter digestibility is associated with high energy value. The lag in digestibilities after moving to a fresh pasture occurred because of fecal carryover. The dotted lines are estimations of digestibility changes as pasture was consumed. The data were obtained by the Chromogen technique (Reid, J.T. et al. J. Animal Nutrition, 46, 1952).

based on daily liveweight gains of one pound. Stated in another way, the 12-months plan produced 236 pounds of liveweight gain per acre from grazing and also 1.65 tons of hay. In making the comparisons, it should be recalled that the acre values for continuous grazing are inflated by about 20 percent because extra cattle were used to utilize the flush spring growth. Much of the spring growth is usually wasted by constant stocking done by farmers using continuous grazing.

Rotational grazing combined with winter harvesting is a practical program because: (1) Feed supplies for constant or variable stocking of cattle for 12 months are provided. (2) High stocking and high yields of animal products per acre are provided for. (3) The production during the flush season is utilized. (4) Different grass-legume mixtures in different fields are grazed or utilized in stages of growth when feed quality is high. (5) It is possible to improve regrowth after grazing or cutting, maintain a better grass-legume balance, reduce plant injury, and maintain stands over longer periods because extreme over- and undergrazing is avoided. (6) The plan is very flexible. Harvested feed may be hay or silage, depending on the facilities and the farmer's desire. The mixtures vary, depending on soils, topography, and other factors. Different plants may be used in separate fields to improve early, mid-season, and late season production. (7) The principle of the 12-months forage program applies widely to agricultural regions in the world. The problem of uneven pasture distribution because of low temperatures, low rainfall, de-

TABLE 15. Animal-days grazing and liveweight gains per acre and per head for continuous grazing and a 12-months feed program (six-year averages).

	Days Grazing Per Acre 700-lb. yearlings	Liveweight Gains Per Head	Liveweight Gains Per Acre
I. Continuous grazing	223 days	1.38 lbs	306 lbs
II. 12-months forage program			
a. From grazing—land area was restricted to amount needed	188 days	1.25 lbs	236 lbs
b. From silage and hay	196 days		196 lbs
TOTAL	384 days		432 lbs
Increase over continuous grazing	72%		41%

Grazing started during early April and ended in October or November. The "days grazing" refers to feed produced per acre, not length of season.

WHY A 12-MONTH FORAGE PLAN? Above: Much of this flush spring pasture growth will be wasted because of understocking. Also, the tall grass shades out the clover, causing less production and lower quality. Below: The growth becomes woody and cattle refuse to eat it. Much of the pasturage on farms is wasted—never converted to animal products.

Nutritive Value of Silages and Hays

The key to a successful silage feeding program is harvesting the plant when the nutrient level is high and the yield of total digestible nutrients (TDN) per acre is optimum. Silages and hays are not complete feeds; they do not satisfy all nutrient requirements, especially for fattening cattle. Table 16 shows typical chemical compositions for corn and alfalfa-orchardgrass silages and hays. As noted, corn silage is low in crude protein and relatively high in nitrogen-free extract (easily digested carbohydrates). With a relatively low fiber and high nitrogen-free extract (NFE) level, corn silage is high in available energy content. Conversely, alfalfa-orchardgrass silages and hays are usually high in protein and low in energy. Corn silage requires supplemental protein but energy content is usually sufficient for high-producing cattle. Grass-legume silage or hay require supplemental energy and may require supplemental protein when cut late.

Factors Determining Silage Feeding Quality

Stage of maturity at harvest and dry matter content control the feeding value of hay-crop silage, hay and corn silage. Table 16 shows the low nutritive value of hay-crop plants when allowed to fully bloom before being harvested. Such feeds also are not readily eaten. Silages and hays are low in concentration of nutrients and should be harvested at a maturity and in a manner that results in highest concentration of nutrients and maximum palatability. Silages are of high feeding value when dry matter content is high as well as being high in protein, minerals and easily digested carbohydrates (NFE) and low in fiber content. High dry matter content improves palatability. With it the animal consumes more silage and more nutrients per unit of silage eaten.

Although high digestibility and high dry matter content are desirable for hay-crop silage and corn silage, due to particular growth characteristics, different approaches are needed concerning their time and method of harvest. In growing perennial legumes and grasses, it is impossible to attain high dry matter yields, high digestibility and high dry matter content in plants, prior to harvesting. Table 17 shows certain characteristics of an alfalfa-grass mixture and demonstrates the basic problems in producing hay-crop silage of high feeding value. As noted, when plant dry matter production increases, digestibility decreases sharply and moisture content of the plant declines slowly. High-producing cattle require a ration which is about 65 percent digestible. As noted in table 17, this would require hay-crop plants to be cut in a relatively early stage of maturity, when moisture content is high and yield per acre is low. High moisture content reduces nutrients per unit of silage and usually results in low palatability unless the forage is wilted before being ensiled.

If hay-crop plants are allowed to mature to reduce moisture level, a silage low in digestibility and palatability results. Table 18 shows the influence of stage of maturity and wilting upon digestibility and dry matter consumption of alfalfa and orchardgrass silage. As noted, alfalfa was not as adversely affected as orchardgrass by delayed harvesting. Digestibility of alfalfa was decreased 5 percent and 10 percent while orchardgrass was decreased 17 percent and 21 percent, respectively, when cut direct and wilted. Alfalfa silage was consumed at a much higher rate than orchardgrass regradless of time of cut or method of harvest. Orchardgrass was extremely unpalatable when ensiled by direct cut and of low feeding value unless supplemented with concentrates. Wilting increased intake of both silages; intake of early cut orchardgrass was particularly improved by wilting.

This information strongly suggests that orchardgrass is responsible for the low palatability of direct cut alfalfa-orchardgrass silage and that the mixture should be wilted before ensiling. The manner in which these factors affect performance of feeder or fattening cattle is discussed in later sections.

Very low average daily gains or losses in bodyweight have often occurred when hay-crop silage has been fed. Poor performance is generally related to unpalatability caused by undesirable fermentation of direct cut high moisture forage, or low digestibility and low palatability caused by late harvesting. The influence of silage moisture content and plant maturity on performance of steers fed alfalfa-orchardgrass silage is shown in Table 19. Dry matter intake and daily gain increased with reduction of moisture content. Reducing silage moisture from 77 percent to 60 percent increased dry matter consumption 50 percent and daily gain 267 percent. The lowest dry matter digestibility, intake, and daily gains occurred with late harvesting when the orchardgrass was in late bloom.

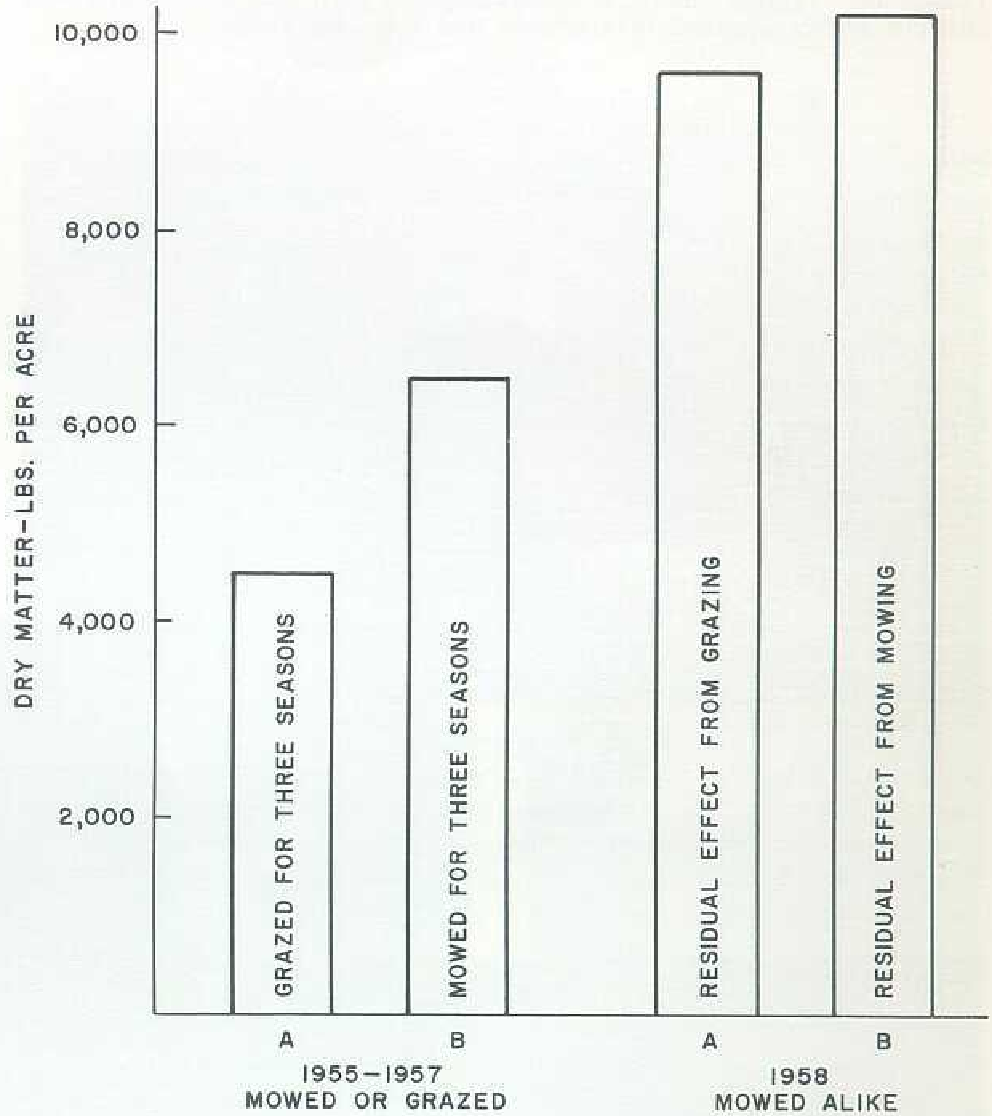


FIGURE 12. During a 3-year period, the yields were higher from mowed than grazed orchardgrass pasture. The harmful effects from grazing were overcome during one winter season.

TABLE 16. Typical chemical composition of corn silage and early and late cut alfalfa orchardgrass silages and hay (dry basis).

Silage	Crude Protein	Ether Extract	Crude Fiber	Ash (Minerals)	Nitrogen Free Extract
	Percent				
Corn Silage	7.6	2.6	20.2	3.3	66.2
Alfalfa-Orchardgrass					
First Harvest Silage					
50% Orch. Headed; Cut Direct	14.1	3.5	31.6	9.3	41.5
50% Orch. Headed; Wilted	17.1	2.5	31.0	9.4	40.0
Orchardgrass Late Bloom	11.2	2.5	33.9	8.3	44.1
First Harvest Hay					
Orchardgrass Late Bloom	11.9	1.6	28.1	7.5	50.9
2nd.-4th. Harvest Hay					
Alfalfa One-Quarter Bloom	16.9	1.9	27.3	8.3	45.6

To obtain highest feeding qualities in corn silage the plant should be permitted to grow until the grain is nearly mature. This is in direct contrast to the practice with legume or grass plants, which must be cut in early growth. The manner in which maturity improves quality of corn silage is shown in Table 20. Corn was cut at six stages of maturity. Total degiestible nutrients (TDN) in the silage dry matter were similar at the stages of maturity, except when the corn was cut very mature. However, the important factor is the amount of TDN in each unit of silage on the "as fed" basis.

As noted, the silage TDN content was almost twice as high at the more

GOOD PASTURE UTILIZATION: An orchardgrass-ladino clover mixture used for silage in early spring and then grazing as part of a 12-month feed program. Orchardgrass heads only during spring because it takes short, cool autumn days to form buds that flower with long days in spring. Thus, orchardgrass with clover cut for silage after seed stems form makes leafy regrowths for grazing, right.

mature stages as at pre-milk maturity. Higher silage TDN enables steers to consume the nutrients required for high gain. Silage TDN, on an "as fed" basis, increases as dry matter content of the silage increases. High dry matter results, in part, from stalk and leaf maturing but is primarily due to the formation of grain which as high in dry matter. High grain content also adds available energy to the silage, which is needed for high gain. At the proper maturity for ensiling about 50 percent of the leaf area will be brown and the grain firmly dented, with some kernels glazed. The length of cut should be short or intake will be reduced.

Silages and Hays for Feeder Cattle

Early cattle feeding experiments at Middleburg tested hay-crop silage during winter for cattle that were to be fattened during the subsequent grazing season.

In an experiment (Table 21) the spring growth of a legume-grass (alfalfa, red clover and orchardgrass) mixture was ensiled with 150 pounds of liquid molasses added at the blower. This silage was compared to the aftermath cuttings of the mixture made into hay. Also, the value of supplemental hay and concentrates was tested. Rations of corn silage and hay and of corn silage, hay and concentrates were control rations. Steers fed the legume-grass silage gained as well as those fed the hay and better than those fed the mixture of legume silage and hay. Feeding three pounds of a ground ear corn and cottonseed meal mixture (2:1 mixture), or 3 pounds ground ear corn per steer daily, increased gains effectively and similarly. Corn silage and legume hay produced higher gains than any of the hay-crop rations. The addition of 3 pounds of the grain mixture to the corn silage and legume hay ration did not improve steer gains.

In another experiment (Table 22) the first harvest of an alfalfa-orchard-

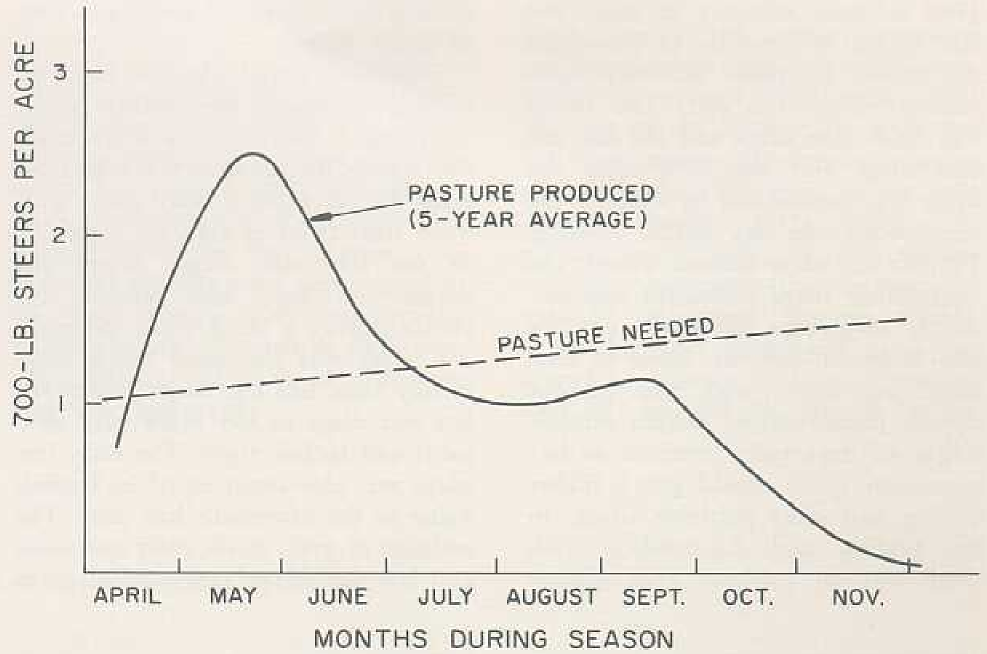


FIGURE 13. The solid curve shows pasture produced in terms of 700-lb. steers per acre each month at Middleburg. These are averages for orchardgrass-ladino clover and bluegrass-white clover pastures. The dotted line shows increased feed needs with season because of weight increases of steers or calves grazing pastures.

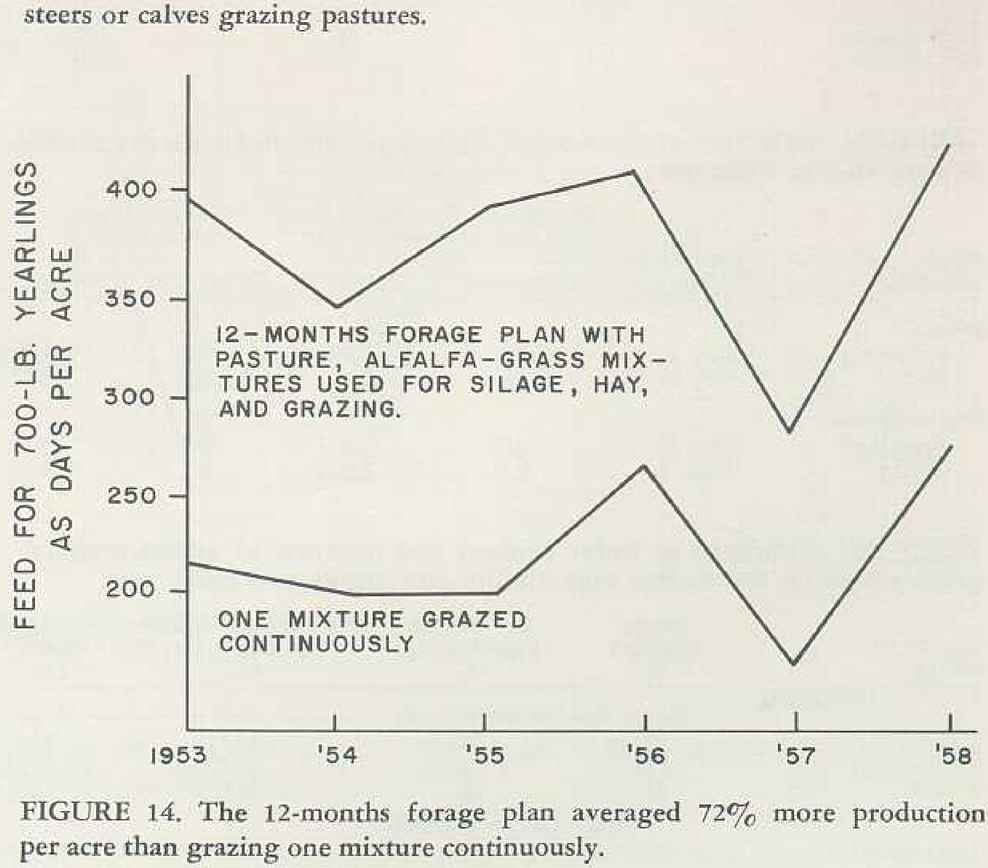


FIGURE 14. The 12-months forage plan averaged 72% more production per acre than grazing one mixture continuously.

grass mixture was cut in early and late stages of growth to determine the effects of plant maturity upon feeding value. The early cut forage was made into silage and the late cut into silage and hay. The early cut silage was semi-wilted by cutting and windrowing the day before ensiling. The late cut silage was not wilted. The semi-wilted silage contained approximately 25 percent dry matter and the late silage, 30 percent. Some of each silage was stored with and without sodium metabisulfite. Sodium metabisulfite was reportedly beneficial to fermentation which would give a higher quality and more palatable silage. In the feeding and digestibility trials there was no evidence that sodium metabisulfite increased feeding quality of either silage.

Digestibility trials showed that early cutting increased digestibility about 10 percent. During two trials when dry matter fed per steer was kept constant for all rations, daily gains were more than twice as high for early cut as for late cut silage. When the silages and hays were offered free choice during a third trial, the early cut silage was consumed much more readily than late cut silage. Steers fed late cut silage or hay made very slow gains and lacked vigor. The early cut silage was also about equal in feeding value to the aftermath hay cuts. The addition of grain to the early cut silage and late cut silage and corn silage to aftermath hay increased gains. This shows that hay-crop feeds are low in energy. However, even with grain, gains were somewhat low, especially for the late cut forage.

Later work showed that low gains when feeding hay-crop silage were associated with high moisture in the forage when ensiled. In an experiment (Table 23) where first harvest alfalfa-orchardgrass was cut early and stored at high moisture (direct cut), average gains were very low and many steers fed the silage lost weight. In contrast, steers fed silage made from the fourth harvest gained at a fair rate although digestibility of silage was lower than with the first harvest silage. The fourth cut silage was higher in dry matter and more palatable; the higher consumption caused higher gains. The adding of grain or corn silage substantially increased the gains of steers fed early cut or fourth cut silages and aftermath hay. The mixture (50-50 dry basis) of fourth cut silage and corn silage was very readily eaten and many cattle showed a fair degree of finish by the end of the trial.

The low palatability of high-moisture early cut hay-crop silage may be overcome by wilting the forage before ensiling, by adding grain to the silage when it is fed, or by adding grain during ensiling (Table 24). The surest and most effective procedure for improving the feeding quality of hay-crop silage was by reducing moisture content of the forage by wilting before ensiling (Table 24). Wilted high dry matter silages were readily consumed, and decidedly higher cattle gains resulted.

TABLE 17. Digestibility and water content of an alfalfa-grass mixture at different stages of growth.

Alfalfa Maturity	Dry Matter Yield Per Cut Tons/Acre	Water %	Estimated Digestibility %
12″ High	0.5	85	75
Prebud	0.8	78	65
1/10 Bloom	1.4	72	60
Full Bloom	1.7	68	50

TABLE 18. Influence of plant maturity and wilting on silage dry matter consumed and digested.

Plant Maturity	Harvest Date	Dry Matter Consumed Per 100 Lbs. Bodyweight, Lb.		Dry Matter Digestibility, %	
		Direct Cut	Wilted	Direct Cut	Wilted
Alfalfa					
Pre-bloom	May 17	1.9	2.4	58	59
Bloom	May 29	1.8	2.0	55	53
Orchardgrass					
Pre-bloom	May 13	0.67	1.8	58	62
Bloom	June 2	0.71	1.3	48	49

TABLE 19. Influence of water content and maturity of alfalfa-orchardgrass silage on dry matter digestibility and intake and daily gain.

Degree of Wilting	Water Content %	Dry Matter Digestibility %	Dry Matter Intake Per Steer/Day Lb.	Daily Gain Lb.
		Pre-bloom Maturity		
Direct Cut	77	59	10.7	0.30
Semi-wilted	73	59	11.4	0.73
Wilted	60	59	16.1	1.10
		Late Bloom Maturity		
Semi-wilted	70	52	10.1	0.23

Fattening Yearling Cattle On Silage Rations

Corn silage is a good feed for fattening beef cattle. Good quality corn silage has almost as much energy as some grains and is a cheap source of feed. High quality corn silage can be produced from corn where 45 to 50 percent of the plant dry matter is grain. Stage of maturity affects animal

TABLE 20. Characteristics of corn harvested at different stages of maturity.

Grain Maturity	Dry Matter	30% Dry Matter Silage	Ears	TDN[1] Dry Matter Basis	TDN[1] As Fed Basis	Dry Matter Intake Per 100 Lbs. Bodywt.
	%	Tons	%	%	%	Lbs.
Pre-milk	22.4	11.1	25.1	70	15.7	1.62
Milk to Dough	26.1	12.0	42.8	69	18.0	1.84
Dough	31.9	13.4	58.3	67	21.4	1.73
Hard Dough to Dent	37.5	17.5	65.4	68	25.5	1.89
Dent to Glaze	46.8	18.0	62.1	70	32.8	1.87
Mature	54.4	24.0	64.9	61	33.2	1.84

[1] Dry basis.

performance since the dry matter intake is affected by the dry content of the silage.

Dry matter intake increased as dry matter content of silage rose to about 40 percent. When fattening cattle were fed corn silage with 27 percent to 50 percent dry matter, the highest gains and feed intake were obtained with 42 percent. Corn silage has a potential of producing one ton of liveweight gain per acre. Also, yield of silage per acre is much higher for the dryer silages. In Virginia and other states it appears that maximum energy yield per acre is obtained when the forage contains about 34-40 percent dry matter. Corn silage may not be a cheap source of nutrients if the corn is harvested before the plant produces maximum digestible energy (Table 25) and/or if the plant population is sparse. Plant population should be high enough to maximize dry matter production and minimize cost per unit of silage.

Cattle fed high quality corn silage plus adequate supplemental protein fatten almost as rapidly as cattle fed liberal amounts of grain, with carcasses about equal in quality (Table 26), and cost of gains is markedly lower. Corn silage produces cheaper gains than when the ear only is used because the whole plant is utilized. When only the ear is harvested, a sizable portion of the plant is lost for feeding purposes. The stalk and leaf supply energy that is 53-55 percent digested for the production of meat and milk. Utilizing the whole corn

SILAGE HARVESTING: Harvesting an alfalfa orchardgrass crop for silage at the Middleburg Station. It is windrowed as mowed and later chopped. Wilting to around 40% dry matter produces a better silage.

TABLE 21. Performance of yearling cattle fed legume-grass hay, legume-grass silage and corn silage rations.

Ration	Average Initial Weight Per Steer Lb.	Average Gain Per Steer Per Day Lb.
Legume-Grass Hay	658	0.90
Legume-Grass Silage	710	0.98
Legume-Grass Silage & Hay	711	0.70
Legume-Grass Silage & Hay + 3 Lb. Grain Mix.[1]	704	1.17
Legume-Grass Silage & Hay + 3 Lb. Ground Ear Corn	770	1.24
Corn Silage & Legume-Grass Hay	669	1.49
Corn Silage & Legume-Grass Hay + 3 Lb. Grain Mix.[1]	582	1.45

[1] Grain mixture consisted of 2:1 ratio of ground ear corn and cottonseed meal.

plant rather than the ear only increases feed energy produced per unit of land area (Table 25), thereby decreasing feed cost per unit of live-weight gain and maximizing meat and milk produced per unit of land area.

Since, as mentioned above, corn silage is deficient in protein, supplemental protein is required. Protein oil meals, such as cottonseed meal, soybean meal and linseed meal are traditional sources of supplemental protein. However, due to their high cost, oil meals increase feed costs .

Urea, a non-protein nitrogenous compound which is converted into protein by the bacteria in the rumen, offers a relatively cheap substitute for protein supplements. Urea has a crude protein equivalent of 281 percent, compared to 40-45 percent for oil meals. Urea has no energy value while the oil meals supply protein and energy. As a safeguard against possi-

TABLE 22. Effects of stage of maturity of alfalfa-orchardgrass silage and hay and energy supplementation on steer gains.

Kind of Silage or Hay	Early Cut Silage[1]		Late Cut Silage[1]		Late Cut Hay[1]		2nd.-4th. Cut Hay	2nd.-4th. Cut Hay+Corn Sil.[2]
Ground Ear Corn, Lb.	0	3	0	3	0	3	0	3
Initial Weight, Lb.	571	545	556	556	546	535	534	562
Avg. Daily Gain, Lb.	0.64	1.17	0.23	0.69	0.28	0.73	0.69	0.82
Avg. Day Matter/Head/Day, Lb.	11.0	11.7	10.2	11.4	10.6	11.3	11.5	11.8

[1] First harvest in spring.

[2] 50:50 hay and corn silage, dry basis.

TABLE 23. Feeding alfalfa-orchardgrass first harvest silage, fourth harvest silage, 2nd.-4th. cut hay alone and with ground ear corn or corn silage.

	Average Initial Weight Lb.	Average Feed Consumed Per Steer Per Day As Fed Lb.	Average Feed Consumed Per Steer Per Day Dry Matter Lb.	Average Gain Per Steer Per Day Lb.
Early First Harvest Alfalfa-Orchardgrass (A-O) Silage				
A-O Silage Only	611	31.9	8.6	0.14
A-O Silage	629	38.4	8.8	1.15
Ground Ear Corn		4.0	3.4	
A-O Silage[1]	612	30.3	6.8	1.21
Corn Silage[1]		19.4	5.7	
Fourth Harvest A-O Silage				
A-O Silage Only	612	45.3	13.6	0.69
A-O Silage	619	44.0	12.8	1.57
Ground Ear Corn		4.0	3.4	
A-O Silage[1]	621	30.0	8.0	1.62
Corn Silage[1]		26.8	8.0	
2nd.-4th. Harvest A-O Hay				
A-O Hay Only	609	17.8	13.9	0.97
A-O Hay	609	15.1	12.0	1.34
Ground Ear Corn		4.0	3.4	
A-O Hay[1]	615	8.7	6.5	1.41
Corn Silage[1]		24.9	7.8	

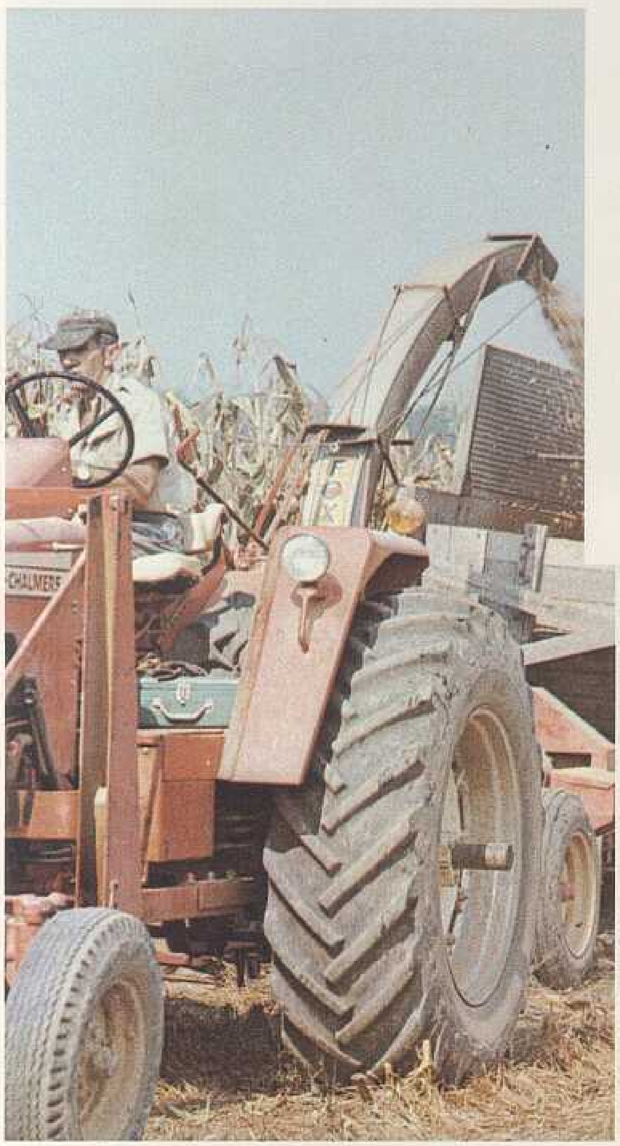
[1] A 50:50 mixture on dry basis.

TABLE 24. Influence of wilting alfalfa-orchardgrass forage and energy supplementation on steer gains.

	Direct Cut Silage		Wilted Silage		Direct Cut Silage with 350 lbs. Ground Ear Corn Ton.
Ground Ear Corn/Day, Lb.	0	8	0	8	7.5[1]
Avg. Initial Wt./Steer, Lb.	745	761	763	766	619
Avg. Gain/Steer/Day, Lb.	0.30	1.68	1.09	1.70	1.99
Avg. Silage/Steer/Day, Lb.	46.7	44.2	37.0	30.4	43.0
Avg. Dry Matter/Steer/Day, Lb.	10.7	16.9	16.1	17.0	13.6

[1] Amount ground ear corn in silage consumed per day.

CORN SILAGE FOR MILK COWS: The dairy cattle research center, showing a corn silage crop in the foreground. The silos and center are used to study methods of intensifying production to obtain high milk production per cow and per acre of land.



ble toxicity and to ensure optimum urea utilization the cattle should be adjusted to urea gradually. Also, sufficient readily-available carbohydrates must be available for the rumen bacteria. Urea may be used in a high urea supplement or it may be added to the silage at ensiling time.

In order to get optimum performance in fattening cattle fed high corn silage rations, an optimum level of protein supplementation is essential. It appears that the optimum digestible protein level for yearling cattle fattened on high corn silage rations is the same as for those fed conventional, high grain rations, namely, 7.5 percent digestible protein, air dry basis (Table 27). Maximum efficiency of gain was obtained at this protein level, regardless of whether urea or cottonseed meal was the supplementary nitrogen (crude protein) source. In fact, when urea was used rate and efficiency of gain were lower for the higher digestible protein level (9.0 percent). This probably indicated mild toxicity from the high level of urea.

In experiments comparing urea to cottonseed meal, steers gained faster and produced higher quality carcasses when cottonseed meal was the source of supplemental protein (Table 27). However, feed efficiency was slightly in favor of the urea-fed cattle. At each protein level total dry matter intake, daily gain and carcass grade were higher for cottonseed meal supplementation.

Addition of urea to corn silage at ensiling time is a simple way to increase the crude protein level of the silage. Different levels of urea, 10, 15 and 20 pounds, per ton of ensilage, were tested for fattening cattle (Table 27A). Generally, feeding only urea-treated silages produced lower rates of gain than feeding regular silage plus cottonseed meal. When cattle were fed corn silage containing 10 pounds urea per ton plus four pounds ground ear corn per head per day, rate of gain was similar to that for those fed the corn silage-cottonseed meal ration. At the higher urea levels performance was lower, even when four pounds of ear corn were fed.

For efficient utilization, urea should not supply more than one-third of the total protein equivalent in the ration. In the case of adding urea to corn silage at ensiling time this would mean 10 pounds urea per ton. Also, the urea should be introduced into the ration gradually over about a two-week period, whether added to the silage or fed in a supplement.

Hay-crop silages may be used to fatten yearling cattle if accompanied with energy supplements. Additional energy may come from corn silage or concentrates. Feeding eight pounds of ground ear corn per steer daily (Table 27B), in addition to hay-crop silage, increased daily gains 333 per cent and 54 per cent, respectively, when direct-cut and wilted silage was fed. Carcass grades were increased by about one grade. A mixture of hay-crop and corn silages plus some supplemental protein and/or energy has produced very satisfactory results for fattening beef cattle. A mixture of 80 parts corn silage and 20 parts hay-crop (dry basis), plus 1.75 pounds cottonseed meal has given acceptable results for fattening cattle (Table 27B).

TABLE 24 A. Dry matter content of corn silage at three stages of maturity and its influence on consumption and daily liveweight gains.

Maturity of grain	Dry matter content of silage %	Dry matter consumed per steer daily Lb.	Average daily gain per steer Lb.
Milk	27	16.7	2.4
Dented	42	19.7	2.7
Dented-Glazed	50	18.8	2.4

The data are averages for three protein supplements made up of cottonseed meal or urea mixtures.

With such quality corn silage and protein supplements, feed costs average around 12¢ per pound of liveweight gain and the potential production is one ton of liveweight gain per acre.

TABLE 25. Digestible energy yield per acre as affected by maturity of corn silage.

	Megacalories Per Acre		
Maturity of Grain	Whole Plant	Stalk and Leaf	Ear and Husk
Milk	9,623	4,553	4,938
Dent	15,009	3,819	11,672

In a later experiment very good performance and carcass quality resulted when a 50-50 mixture (dry basis) of hay crop silage and corn silage plus four pounds of ground ear corn and 2.0-2.5 pounds of protein oil meal was fed (Table 27C). Using only ground ear corn or cottonseed meal with 50-50 mixtures produced acceptable gains and carcasses. The better performance in this experiment than in the earlier one (Table 27B), when hay-crop silage made up only 20 percent of the forage dry matter, was due to better quality of corn silage, a higher level of protein in the ration and the fact that stilbestrol implants were used in the steers

THE BEEF HERD: RAISING CALVES EFFICIENTLY

The purebred Angus beef herd was started by purchasing heifers from various herds in 1949. All female replacements have been produced by the herd. This 65-cow herd is operated like a commercial herd and it is used to evaluate forages with cows and their calves, later steers and heifers. This section deals with efficient methods of raising calves, an important part of the research.

The cows have been managed in a simple and practical way; they have no shelter and have had grain only occasionally in experimental treatments. Some of the cows are over 16 years old and have averaged a calf each year. At the Middleburg station, a late summer (July-September) calving program with breeding seasons of about 75 days (October 1-December 15) has been used. Calving is 80-90 percent completed by August 20. The herd is pastured from early April to early December and is fed in dry lots during winter to study feeding rates and methods of cows and calves. Prior to December, the calves graze and eat with the cows.

During early December to mid-March when the calves are three to eight months old, the cows have been fed on very low to liberal rations with which they lose or gain weight, to see how this affects the gains of the nursing calves and the next calf crop. The nursing calves were also handled in different ways, getting only milk from the cow, milk from the cow and various kinds of feeds in the creep, and weaning early. This section shows that it does not pay to feed a cow raising a three to four month-old calf liberally; the calf gains depend primarily on the creep feed.

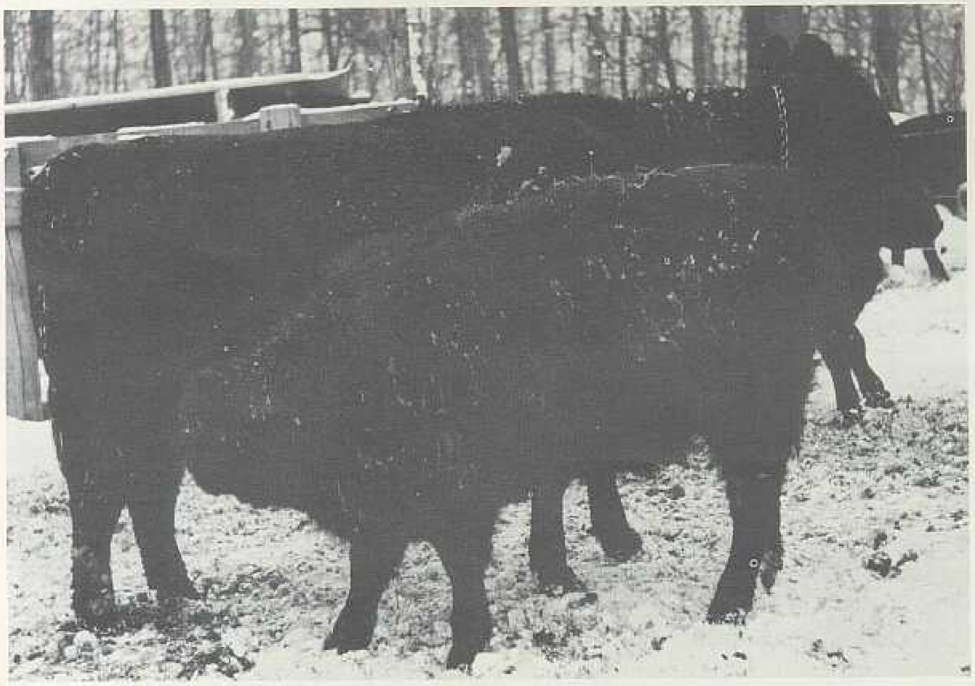
TABLE 26. Performance of steers fed corn silage plus cottonseed meal or a conventional high grain fattening ration.

	Rations	
	High Corn Silage	High Grain
Final Weight, Lb.	1017	1020
Daily Gain, Lb.	2.6	2.7
Feed Per Day, Lb.		
Corn Silage	41.0	15.0
Alfalfa-Orchardgrass Hay		2.0
Cottonseed Meal	4.1	3.2
Ground Ear Corn		13.5
TDN/Lb. Gain, Lb.	5.5	6.3
Feed Cost/Lb. Gain	15½¢	21¢
Carcass Grade [1]	12.0	12.6
Dressing %	58.7	57.6

[1]Code: Low choice—12; average choice—13; etc.

These experiments were usually conducted with units of five cows and their calves per treatment and were duplicated over a two- or three-year period. Feeding trials usually lasted 100 days. Care was taken to assign similar cows and calves to the groups before starting the experiments. There was no shelter for the cows in quarter acre dry lots; the calves could go into a small building with the creep feeds. The experiments were designed to see if forages could be used to raise calves more cheaply.

There was not land enough to compare spring calving with the late summer calving used at Middleburg. Summer calving has been very successful, averaging about a 90 percent weaned calf crop, beginning with the first calves in 1951. Summer calving has the following advantages: (1) the summer temperatures favor high calf survival during the calving period, (2) a minimum amount of feed is needed for the cows during the winter, (3) it is an excellent way to utilize pastures and crops, and (4) it is a way to get a high-quality, liberal feed supply making for fast and consistently good growth of calves. However, the best season for calving beef cows to produce the most calves per acre of land at the lowest costs is not known.



FAST GROWTH WITH SILAGE: Calves three to eight months old that nursed and were fed quality corn silage with a little cottonseed meal gained 2.0 pounds daily. Similar calves restricted to nursing gained 0.33 pounds daily.

Value of Milk from Beef Cows

The chief "road block" against good feed efficiency in producing beef calves is the idea that the cow's milk is the main source of nutrients for calves up to seven or eight months of age. Because of this, the cow may be given excessive pasture or other feeds for high milk production that actually doesn't occur. At Middleburg, it was found that only for maximum gains was milk important after calves were three to four months of age.

In one experiment, the liveweight gains of calves managed in three ways were measured. Some received milk only from mother cows, others had milk and creep feed, and a third group was weaned at three to four months of age. The creep-fed and early weaned calves were fed corn silage, alfalfa-orchardgrass hay and a concentrate mixture, all free choice. The calves getting only cow's milk gained

TABLE 27. Levels of urea and cottonseed meal supplementation to a full feed of corn silage for fattening cattle.

	Steer groups					
Digestible Protein Level,[1] %	6.0	7.5	9.0	6.0	7.5	9.0
Cottonseed Meal, Lb.	1.5	2.6	4.1			
Feed Grade Urea, Lb.				0.16	0.33	0.49
Slaughter Weight, Lb.	1078	1079	1116	1027	1057	1022
Daily Gain, Lb.	2.54	2.72	2.85	2.4	2.6	2.4
Daily Feed, Lb.						
Silage	48.8	47.1	46.0	46.2	46.8	46.4
Cottonseed Meal	1.5	2.6	4.1			
Urea				0.17	0.34	0.50
TDN/Lb. Gain, Lb.	5.43	5.20	5.23	5.10	4.76	5.12
Carcass Grade[2]	12.5	12.5	12.3	11.2	11.5	11.5
Dressing %	57.3	57.1	57.9	56.1	56.1	56.4

[1] Air dry basis.
[2] Code: High good—11; low choice—12; etc.

These liveweight gains from primarily corn silage were produced at costs of 9½ to 12¢ per pound.

TABLE 27A. Peromance of steers when fed urea-treated silages compared to regular silage and protein supplement.

	Regular Corn Silage	Urea Treated Silages					
		10 Lb. Urea/Ton		15 Lb. Urea/Ton		20 Lb. Urea/Ton	
Ground Ear Corn, Lb.		0	4.0	0	4.0	0	4.0
Cottonseed Meal, Lb.	2.7	0	0	0	0	0	0
Slaughter Weight, Lb.	1170	1098	1178	1075	1163	1059	1124
Average Daily Gain, Lb.	2.5	2.0	2.5	2.0	2.3	2.1	2.2
Silage Dry Matter/Day, Lb.	18.9	17.4	16.6	17.7	15.5	15.4	14.8
Carcass Grade[1]	11.7	11.3	11.8	11.7	11.5	11.2	10.5

[1] Code: average good—10; high good—11; low choice—12; etc.

TABLE 27B. Influence of corn silage and ground ear corn upon performance and carcass quality of fattening steers fed high moisture and low alfalfa-orchardgrass silages.

	HMS[1] Alone	HMS[1]+ 8 Lb. GEC[3]	20% HMS[1] 80% C. Sil. 1.75 Lb. CSM[4]	LMS[2] Alone	LMS[2]+ 8 Lb. GEC[3]	20% LMS[2] 80% C. Sil. 1.75 Lb. CSM[4]
Daily Gain Per steer, Lb.	0.30	1.7	1.8	1.1	1.7	1.8
Silage Per Steer Per Day, Lb.						
High Moisture Silage	46.7	44.2	14.5			
Low Moisture Silage				37.0	30.4	8.1
Corn Silage			39.9			40.3
Dry Matter Per steer Per Day, Lb.	10.7	16.8	17.2	16.1	19.5	17.4
Carcass Grade[5]	7.9	10.7	11.4	9.3	11.3	11.3

[1] HMS—high moisture alfalfa-orchardgrass silage
[2] LMS—low moisture alfalfa-orchardgrass silage
[3] GEC—ground ear corn
[4] CSM—cottonseed meal
[5] Code: 8.0 = High standard, 9.0 = Low good; 10.0 = Average good; 11.0 = High good; etc.

TABLE 27C. Influence of protein and energy supplementation when feeding a mixture of high or low moisture alfalfa-orchardgrass silage and corn silage.

	High Mois. A-O Sil. 50%—Corn Silage 50%[1]			Low Mois. A-O Sil. 50%—Corn Silage 50%[1]		
Ground Ear Corn, Lb.		4.0	6.6		4.0	6.1
Cottonseed Meal, Lb.	2.4	2.7		1.7	2.1	
Daily Gain Per Steer, Lb.	2.3	2.5	2.3	2.2	2.4	2.4
Dry Matter Per Steer, Lb.	17.5	19.3	17.5	18.6	20.0	19.2
Carcass Grade[2]	10.6	11.3	11.2	10.9	11.9	11.0

[1] Dry basis.
[2] Code: average good—10; high good—11; low choice—12; etc.

0.33 pounds daily while the creep-fed calves gained 2.0 pounds and those weaned, 1.7 pounds daily. These results show that the milk does not supply enough feed for calves. Measuring milk flow by weighing calves before and after nursing showed that cows fed to maintain their body weight produced 6.0 to 7.5 pounds of milk daily, six to seven months after calving. This amount of milk could not supply enough energy for fast calf growth; hence, supplemental feed was necessary. Feeding calves by turning feed into milk by cows is poor use of feed. Calves getting only milk needed 44 pounds total digestible nutrients-TDN (about 80 pounds of hay) per cow-calf unit per pound of calf gain, while those creep fed required nine pounds and those early weaned, 10 pounds.

Some milk is needed for high calf gains, as the nursing-creep fed calves gained more than the early weaned calves. Cows fed on very low rations and losing one pound bodyweight daily produced only four to five pounds of milk; however, their calves gained as well as calves whose dams were fed to gain weight. As milk flow is reduced, the calf consumes more creep feed, but this is small as compared with savings in feed for cows fed low rations. Therefore, the limiting of feed to cows and direct or creep feeding the calves lowers the feed costs per raised calf.

Feeding Rates of Cows

Feed for cows makes up about 50 to 60 percent of all costs for raising a beef calf. It is inefficient to feed brood cows above a level for a potential of 100 percent reproduction. To get high feed efficiency, the amount of feed for cows should be controlled as can be done by feeding less during winter and using higher stocking rates on pasture. Such feed restrictions for cows must not hinder growth of the calves; otherwise, feed costs increase. The amount of feed for cows may be very low if the calves are creep fed. Figures 15 and 16 show liveweight gains of cows and calves with different feeding rates for cows. Cows were fed: (a) 14.4 pounds TDN (about 26 pounds of hay) per cow daily (100 percent rate of forage), (b) 11 pounds TDN (75 percent rate of forage), and (c) 10 pounds TDN daily (four pounds of grain and 50 percent as much forage as in [a]). There were two groups of cows for each feeding rate; the nursing creep-fed calves were fed in two ways: (1) alfalfa-orchardgrass hay and corn silage and (2) the same plus a ground grain mixture. The calves were confined to the creep feeding area while the cows ate; the calves had free choice creep feed at all times.

Note the cows with liberal feed (100 percent rate) gained 0.52 pounds daily; the two groups of cows with less feed lost .24 to .37 pounds liveweight daily (Figure 15). The daily gains of the calves for the three groups of cows were similar. However, the nursing creep-fed calves fed forages and grain gained 2.2 while calves with milk and forages gained 1.8 pounds. These data show cows do

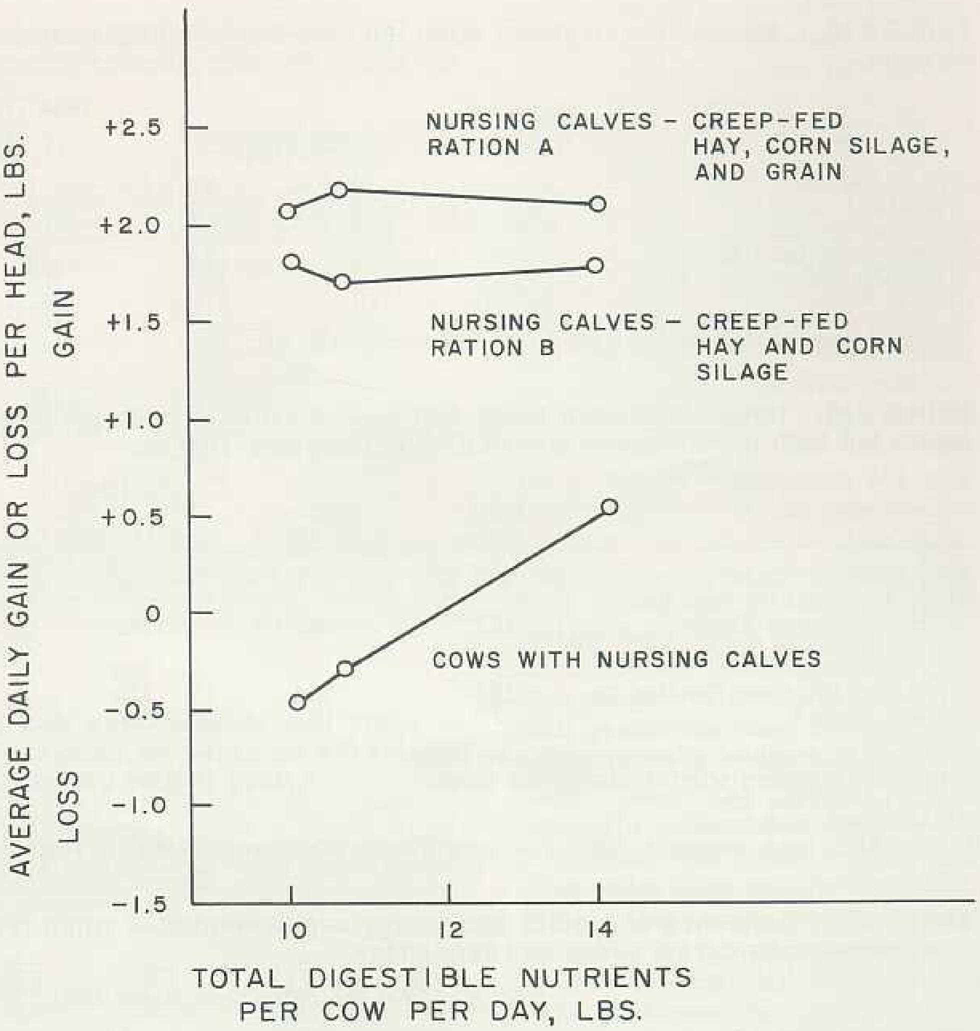


FIGURE 15. Effect of feeding rates of cows on daily gains of cows and calves. Each lb. of TDN is about equal to almost 2 lbs. of good hay. The body weight changes for the two groups of cows with sucking calves (one group for the A and one for the B calf rations) are averaged.

not need grain; the cow herd has not been fed concentrates since 1956.

In another experiment (Figure 18), cows with nursing and early weaned calves were fed at seven, nine, and 11 pounds TDN daily. The seven pounds TDN is equal to about 13 pounds of good alfalfa-orchardgrass hay; this is about 58 percent less feed than recommended for such cows. The cows fed 11 pounds TDN (about 20 pounds of hay) maintained their bodyweight; the other cows lost weight, those fed seven pounds TDN lost about 1.2 pounds daily for the 100-day experiment during three winters. The saving of feed by forcing low nutrition of cows when calves are three to eight months old while feeding the calves liberally, is efficient use of feed.

The daily gain of the nursing creep-fed calves averaged about two pounds regardless of the cows' feeding rate. The calves ate a little more corn silage when the cows were fed at low rates. Thus, as there was less milk with lower feeding rates, the calves adjusted by eating more creep feed. Milk production was seven, 6.3, and 5.2 pounds daily for cows fed 11, nine, and seven pounds TDN. Bodyweight of dry cows was maintained with less feed; seven pounds TDN maintained bodyweight while the nine pound and 11 pound rates increased bodyweight four percent and seven percent, respectively. Therefore, early-weaning the calf will effectively reduce feed required for the cow.

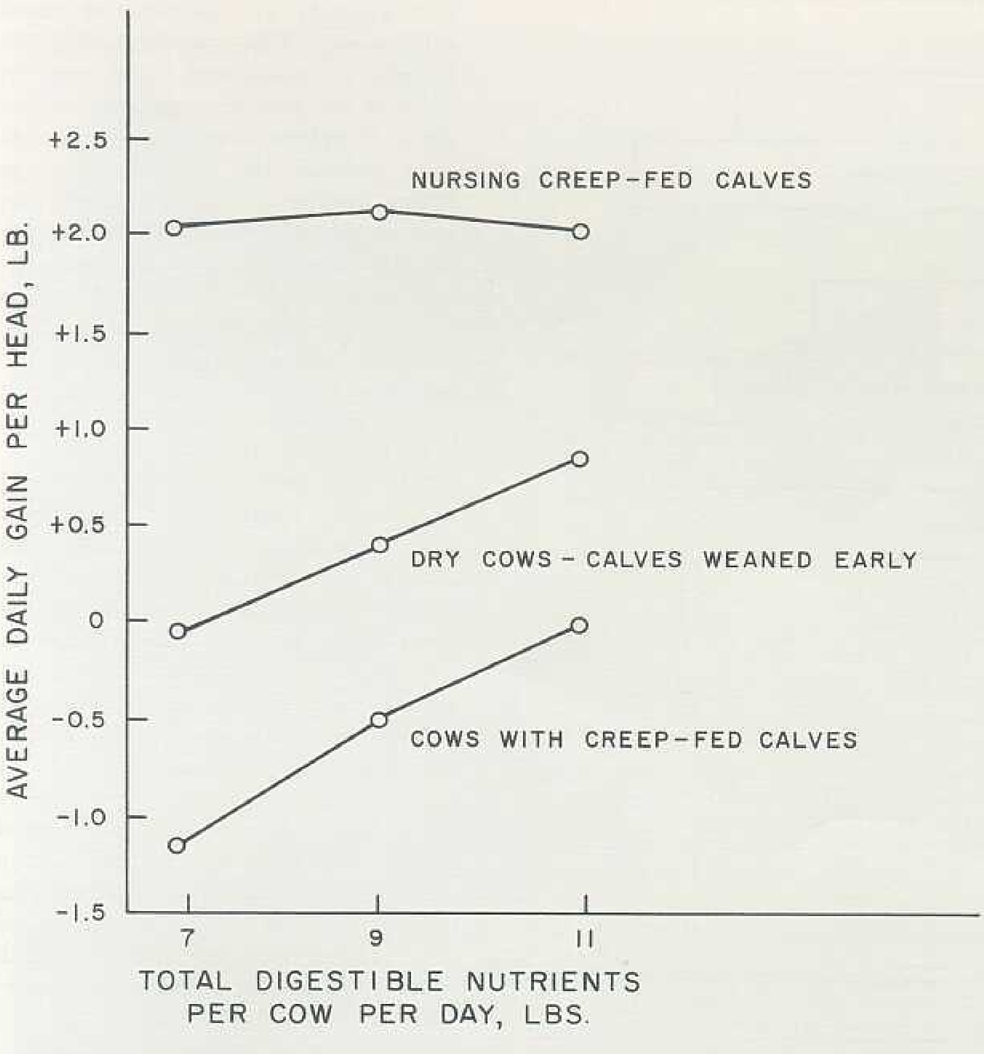


FIGURE 16. Dry cows and cows with sucking calves were fed 7, 9, and 11 lbs. total digestible nutrients (13, 16, and 20 lbs. of hay equivalent) daily. The sucking calves were fed corn silage and cottonseed meal in creep feeders.

There was no harm to cows from such low rates of feeding while calves were three to eight months old. During 14 years, the conception rate has averaged 95.5 percent and the weaned calf crop 90.0 percent. After winter, the cows were pastured; the cows with the low feed rates gained about five pounds daily during the first 30 days on pasture and by July 1 were only about 30 pounds lighter than the cows with the highest winter feeding rate. During three years, birthweights of calves from cows fed seven, nine, or 11 pounds TDN were similar, averaging 71.5, 67.0, and 69.5 pounds per calf, respectively.

Silage, a Good Feed for Calves

Pasture, silage, and hay are generally thought to be of limited value to calves. Calves digest and use quality silage, however, about as well as cows. During two winters, weaned calves (five to six months of age) digested about 70 percent (dry basis) of corn silage and 60. percent of alfalfa-orchardgrass hay or silage. Corn silage with a little supplemental protein is an excellent creep feed. Alfalfa-orchardgrass hays and silages are not as good an energy source as corn silage. Calves eat more hay than they do of the same crop made into unwilted silage. Alfalfa-orchardgrass wilted to 35 to 40 percent dry matter before ensiling was like good hay.

Figure 17 shows the daily gains of nursing calves with different creep-fed rations ranging from entirely silage or hay to all concentrates. The experiments were done over a period of years but all the results are averages for two or three years. When nursing calves had creep feeds of corn silage, alfalfa-orchardgrass hay or silage, the daily gains averaged about 1.75 pounds. Adding energy (three pounds daily of ground shelled corn) to alfalfa-orchardgrass silage or hay, and protein (1.5 pounds of cottonseed meal daily) to corn silage increased the liveweight gains of calves to two pounds. Feeding concentrates to nursing calves gave daily gains of 2.1 pounds. Feed efficiency (excluding the cows' feed) ranged from 2.5 to 3.2 pounds of TDN per pound of liveweight gain by calves. Liberal feeding of a grain mixture gave lower feed efficiency than feeding rations high in forages. The average weight for nursing calves creep fed corn silage plus 1.5 pounds cottonseed meal has been about 500 pounds at eight months of age. To obtain such high gains, corn silage as a creep feed should be fed five percent above consumption and hay crop forages at 15 to 20 percent excess.

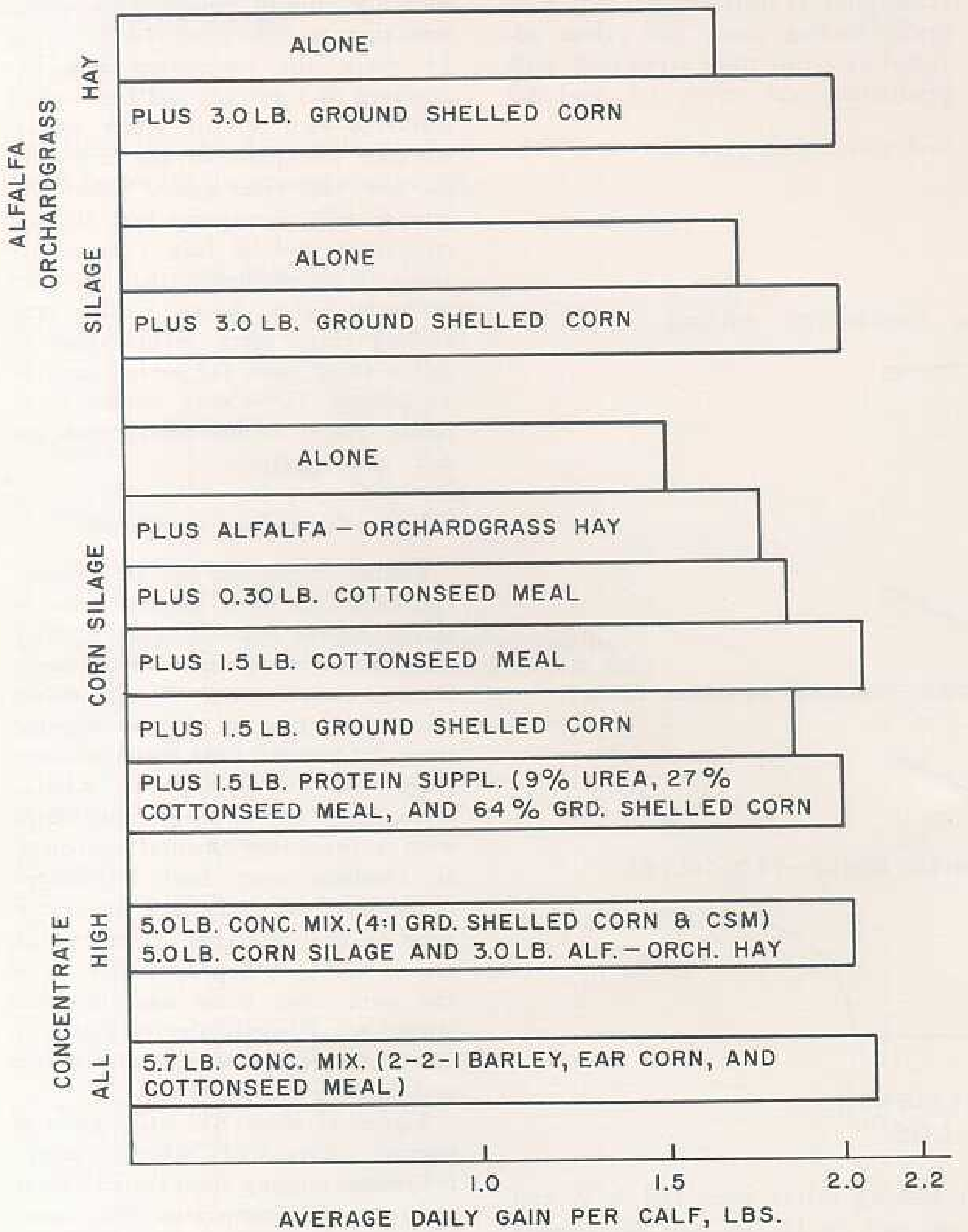


FIGURE 17. Average daily gains of sucking creep-fed calves for high forage or high concentrate rations.

Corn silage containing 50 percent grain is an exceptionally good feed for calves. It is consistently high in digestible energy and palatability, uniform in quality, easy to feed, and relatively low in cost. It is high in energy; protein, in addition to that obtained from the cow's milk, is needed for high calf gains. As noted in Figure 17 daily gains were higher with 1.5 pounds than with 0.3 pounds of cottonseed meal supplement. Also, supplementing 0.3 pounds of cottonseed meal was as good as 1.5 pounds of ground shelled corn. Supplementing ground shelled corn reduced the amount of silage eaten, apparently due to insufficient protein. Urea, a non-protein nitrogen compound costing much less than protein oil meals, may be used to replace a portion of supplemental protein. Urea has no energy value; it must be fed at low rates and mixed in with rations so intake is controlled to prevent urea toxicity.

The excellent gains of early weaned calves, three to four months old, show that corn silage is an excellent high energy feed (Figure 18). When such calves without milk were full fed on corn silage plus 1.5 pounds cottonseed meal, the daily gains averaged 1.5 to 1.8 pounds. This is 0.50 to 0.30 pounds less than for nursing calves, but it shows that young calves obtain most of their nutrient requirements from quality corn silage. Early weaned calves will gain as fast as nursing calves (first column vs. last column (Figure 18) if milk substitutes and concentrates are fed; however, such rations are too expensive to be practical.

Management and Feeding Practices

The cows and calves must be managed to control the quality and amount

TABLE 28. Influence of creep feeding and separation of cows and suckling calves on liveweight gains and feed efficiency.

	Creep feeds and calf management			
	Alfalfa orchardgrass hay and 3 lb. grain per cow and calf		Corn silage and 1.5 lb. cotton seed meal per calf	
	LOT 1	LOT 2	LOT 3	LOT 4
	No creep feed—calf feed added to cow ration Calves ate with cows	Creep fed Calves ate with cows	Creep fed Calves ate with cows	Creep fed Calves separated while cows ate
Average Daily Gain/Calf	+ 1.40 lb.	+ 1.86 lb.	+ 1.98 lb.	+ 2.04 lb.
Average Daily Gain or Loss per Cow	+ 0.31 lb.	− 0.93 lb.	− 1.00 lb.	− 0.52 lb.
TDN per Cow & Calf Daily	16.8 lb.	15.9 lb.	14.9 lb.	16.4 lb.
TDN Consumed Daily Per Calf From Creep Feeding	—	4.9 lb.	3.9 lb.	5.4 lb.
TDN per Lb. of Cow & Calf Gain	9.8 lb.	16.7 lb.	14.8 lb.	10.5 lb.
TDN per Lb. of Calf Gain	12.0 lb.	8.3 lb.	7.3 lb.	7.8 lb.

The cows in lots 2, 3, and 4 were limited to 11 lb. TDN daily as orchardgrass-alfalfa hay (11 lbs. TDN is equal to about 20 lbs. of hay).

of feed eaten by the cow and her calf. Separating calves and cows while cows are fed and eating gives the best feed control and use of feed, especially when nutrition for cows is held at low rates and when nursing calves are creep-fed.

The daily gains in Table 28 show how the cows and calves interfere with each other. Feed eaten other than milk by calves, three through eight months old, is directly associated with rate of gain. When calves without creep feed and cows ate together, the calf gains were 1.40 pounds as compared with 1.86 pounds for the creep-fed calves (compare lots 1 and 2, Table 28). The feed per cow-calf unit was similar, but the gains without creep feeding were one-third less because the calves had to compete with cows for feed.

In another set of comparisons in Table 28, the creep-fed calves had corn silage and cottonseed meal and the cows on low nutrition were fed about 20 pounds of hay (11 pounds TDN) daily (compare lots three and four, Table 28). With cows and creep-fed calves together, the cows lost one pound daily, twice the weight losses when calves were separated from cows while they ate. Although the calves had excess creep feed, they caused the cows to lose weight by eating some of

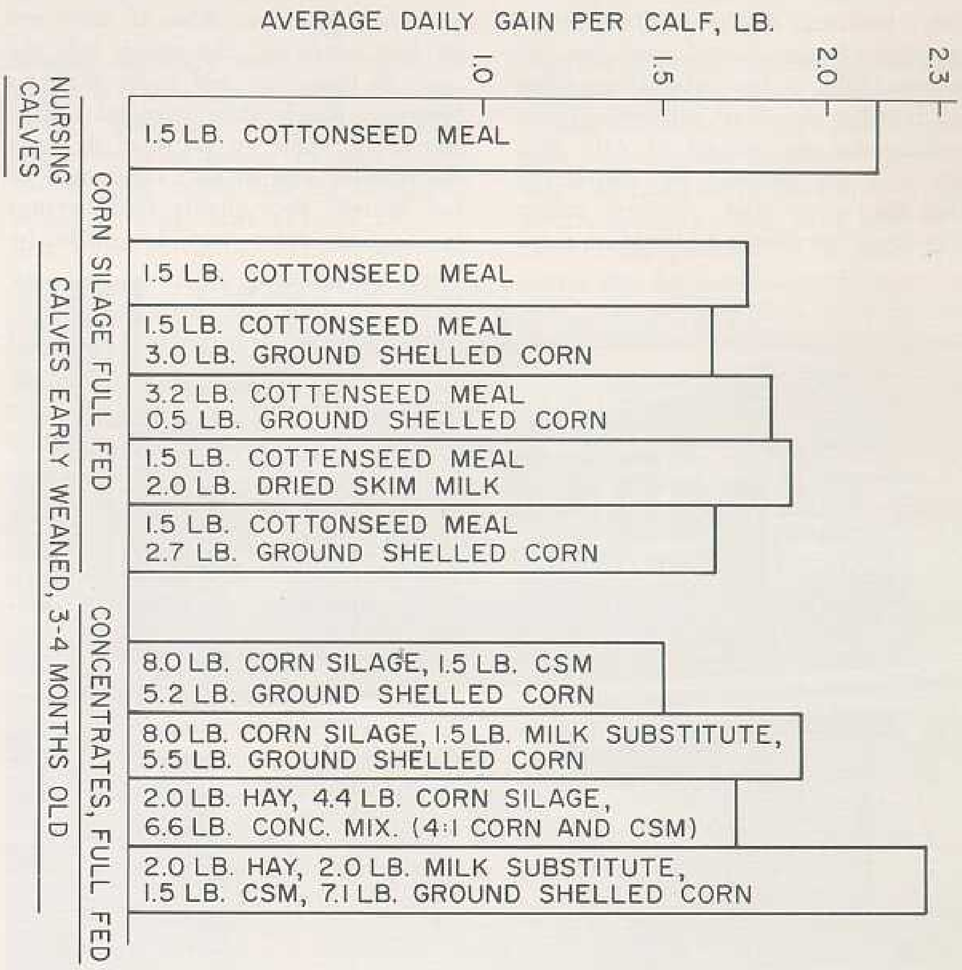


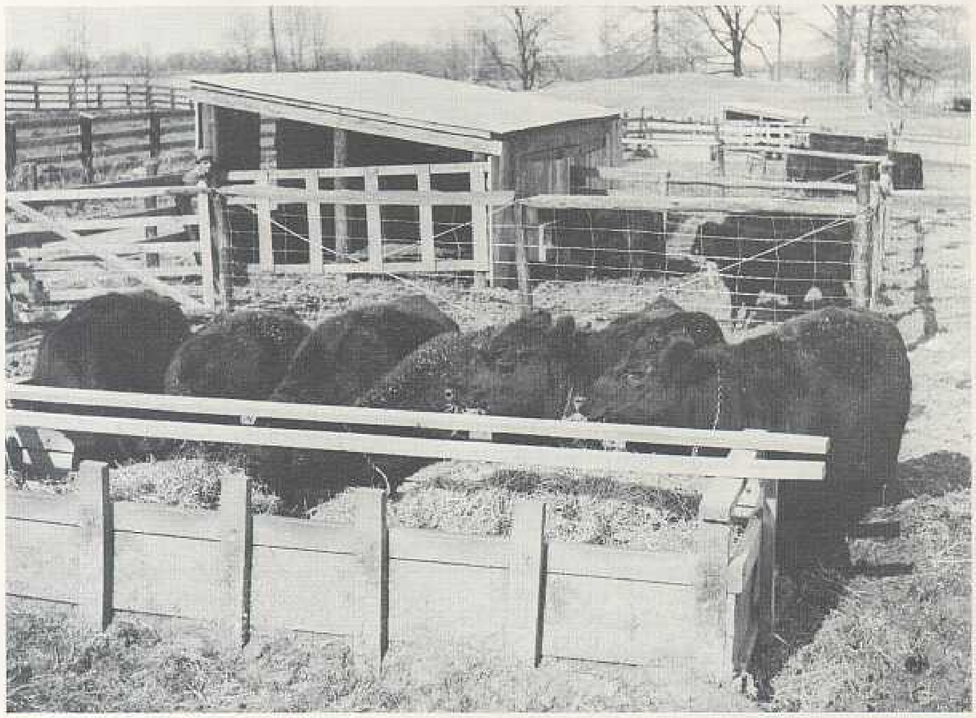
FIGURE 18. Average daily gains of early weaned calves fed high or low forage rations.

their feed. Calves that were with cows at all times ate 28 percent less from the creep-feeders than the calves separated from the cows while being fed. Thus, even though the calves were creep-fed, they ate considerable amounts of the cows' feed. The liveweight gains of the creep-fed nursing calves separated or eating with the cows were similar.

Feed efficiency is based on the feed consumed by the cow and her calf. The best feed efficiency for raising calves occurs with high calf gains obtained with creep feeding, together with low feeding rates of cows. Note in Lot 1, 12 pounds of TDN were needed per pound of liveweight gain from the calves, where the cows gained .31 pounds and the calves 1.40 pounds daily; however, in Lot 2, where calves gained 1.86 pounds and cows lost .93 pounds daily, it took about one-third less feed per pound of calf gain. Thus, feed needed per pound of calf gain was cut 29 percent by restricting feed to cows and feeding calves liberally. Feed efficiency based on gains of calves is the most important consideration, as cash income from herds depends on calves.

Data on feed efficiency for the combined gains of cows and calves are also given in Table 28; however, these values are not important unless cows are sold.

The feed savings by enforcing low nutrition of cows and high nutrition of calves is most successful when cows and their nursing calves are separated while the cows eat. The average daily gains of calves will be improved if they are handled to make them eat the feed intended for them, rather than eating the cows' feed. If calves are fed corn silage and permitted to eat with cows fed hay, they will eat too much hay as compared to corn silage and thus gain less. Also, if cows are on low nutrition, the calves rob the cows of some hay and cause them to lose more weight than intended. Calves should be made to eat feed of high digestibility and intake; cows may be fed "rough" poor quality feed. Savings in feeding cows can be made by limiting the amount of good quality forage or by feeding poor late hay.



CALVES ARE PENNED in creep feed area while cows eat. There are eight such lots for experimental work with cows and their calves.

Feeding Rates of Cows and Methods of Separating Cows and Calves

This experiment with dry cows or with nursing calves was made to find out how much feed cows need for best feed efficiency for raising calves. In addition, methods of separating cows and calves were investigated. The cows were fed at 20, 11, and seven pounds of TDN (20 pounds of TDN is equal to 36.5 pounds of good hay). The calves were managed in four ways: (1) calves were penned in their creep feed area morning and night for one hour while the cows ate, (2) the creep-fed calves and cows were put in separate pens and nursing was through a board fence (fenceline nursing), (3) calves were free to eat with cows but with no creep feed, and (4) calves were weaned when three to four months old. The five cow-calf management programs are given in Table 29. Note especially the daily gains of calves and the savings in feed per pound of calf gain in the right column of Table 29.

Program A: Here cows and calves were fed together, a common practice for summer-fall calving cow herds. The cows stayed fat at the expense of low calf gains. Each pound of calf gain required 12 pounds of TDN, a low feed efficiency and a calf low in market value.

Program B: The creep-fed calves ate with the cows, a common farm practice. Creep feeding greatly improved calf gains and market value. Here feed efficiency depends on the amount of feed per cow. As noted, feed efficiency based on calf gains was not improved over *Program A* when the cows were fed liberally. Reducing the feed per cow to cause weight losses increased the feed efficiency to only 7.3 pounds of TDN per pound of calf gain.

Program C: The calves were penned in their creep feeding areas with

TABLE 29. Influence of feeding rates of cows, early weaning, creep feeding, and separating cows and calves on liveweight gains and feed efficiency.

	Cow Feeding Rate	Lbs. TDN fed daily[1] Per Cow	Per Calf	Lbs. liveweight gain daily Per Cow	Per Calf	TDN per Lb. Liveweight Gain Per Cow & Calf[2]	Per Calf[2]
			Calves free to eat with cows, no creep feed				
Program A:	High	— 16.2 lb.	—	+0.31	+1.40	9.8 lb.	12.0 lb.
			Creep-fed calves free to eat with cows				
Program B:	Very High	20.0	2.6	+0.24	+1.90	10.6 lb.	11.9 lb.
	Moderate	11.0	3.9	−1.00	+1.98	14.8 lb.	7.3 lb.
			Calves penned in creep-fed area while cows ate				
Program C:	Moderate	11.0	5.5	−0.13	+2.06	8.5 lb.	8.0 lb.
	Very Low	7.0	5.8	−1.19	+2.04	15.0 lb.	6.3 lb.
			Creep-fed calves penned from cows, fenceline sucking				
Program D:	Moderate	11.0	5.7	+0.26	+2.06	7.2 lb.	8.1 lb.
	Very Low	7.0	6.0	−1.11	+2.04	14.0 lb.	6.4 lb.
			Calves early weaned, cows dry				
Program E:	Moderate	11.0	6.3	+0.76	+1.71	7.0 lb.	10.1 lb.
	Very Low	7.0	6.3	−0.11	+1.71	8.3 lb.	7.8 lb.

[1] 20, 11, and 7 lbs. of TDN are equivalent to about 36, 20, and 13 lbs. of good hay.
[2] Based on feed eaten by cows and calves.

quality feed while the cows ate, a practice not yet used by farmers. Daily gains of calves were consistently high and bodyweight losses of cows were low and effectively controlled. Control of weight losses by cows made it possible to feed cows at very low rates (seven pounds TDN or 13 pounds hay daily). Because much less feed was needed per cow, the feed efficiency was very good, only 6.3 pounds TDN per pound of calf gain (Table 29).

Program D: Here the cows and calves were in separate adjacent pens; the calves nursed through a fence line. The calves gained a little more than two pounds daily, and this plan was easy on cows. The calves nursed an average of two times daily, while those with *Program C* averaged three nursings. The fence line nursing cows spent one hour more daily lying down, and lost less weight than where calves were free to nurse. This system was an efficient feed saver, especially when the feed for cows was severely restricted.

At weaning time, the board fence was closed to stop nursing. The calves continued to gain weight during weaning; conventionally weaned calves lost considerable weight. If this were considered, efficiency would be highly in favor of fence line nursing. No particular problems were encountered; the cows were forced to walk along the nursing fence line by a special fencing arrangement (Figure 19). At first, a few calves had to be encouraged to nurse, but after 48 hours no attention was needed.

Program E: Early weaning gave a somewhat lower feed efficiency than that for nursing calves. However, the feed efficiency could have been improved by restricting feed for dry cows. Note that with seven pounds TDN daily, the dry cows lost about a pound less daily than cows with nursing calves. However, early weaning is not the solution to higher feed efficiency unless gains of calves are improved to make market weights and grades comparable to those of calves raised with some milk from the cow.

Feed used per pound of liveweight gain of cows and calves combined is also given in Table 29. However, these data are not really practical unless the cows are sold.

Restricting feed for cows with nursing calves three to eight months old has practical application. It is clear that the liveweight gains of calves can be kept high by creep feeding. This system is really a high stocking rate that increases the liveweight gains in terms of calf production per acre. This research clearly shows that beef cows and calves perform at a high level under dry lot conditions. Feeding the cow herd in dry lot offers an excellent opportunity to increase efficiency in the use of land and feed. Removing the herd from pasture land, and growing plant species more productive than those generally used for pasture, would significantly increase the calf liveweight gains from a given land area. It is quite evident that corn and alfalfa will satisfy most feed needs. Feeding in dry lot offers an excellent opportunity to maintain efficiency by altering the feeding level of cows to meet the nutritional needs at any given time.

Some method of restricted feeding of cows must be developed for spring calving where cows with nursing calves are pastured. With present methods of raising beef cattle, the cows get more good feed than they need. Pastures are stocked lightly so calves get enough to eat since they must compete with cows. Heavy stocking and creep feeding of calves may be a way to maintain high live-weight gains of calves and more gain per acre of pastures. The present low stocking rates of beef cattle causes low production per acre and often makes raising beef calves a marginal business.

THE DAIRY HERD AND RESEARCH FINDINGS

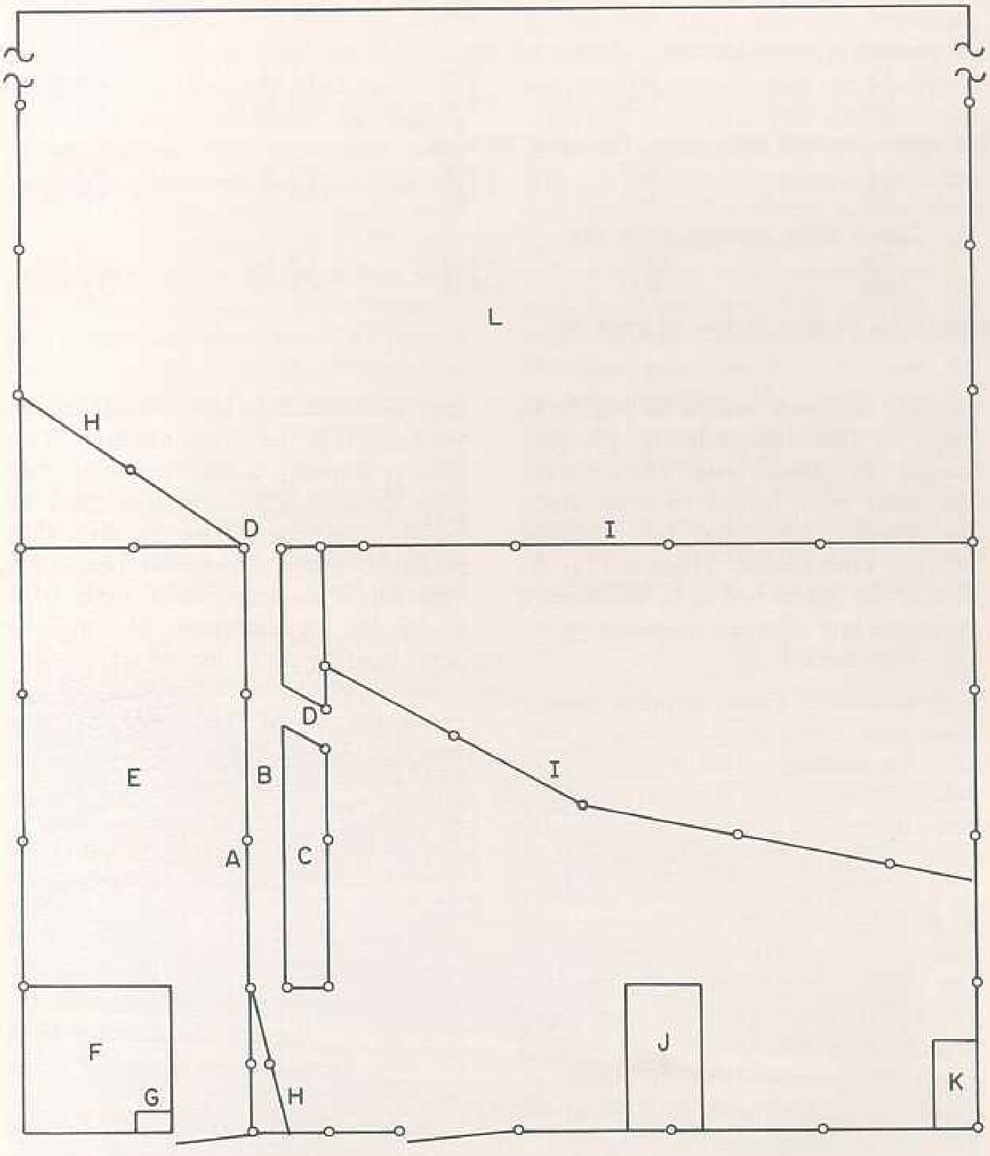
The purebred Holstein herd of about 60 cows is used to evaluate forages for efficient, high quality milk production. Methods of raising calves and using low-cost forages are also being investigated at Middleburg.

Lactating dairy cows require much more energy, protein, and other nutrients than less productive ruminants. Because of this, lactating cows serve as a good yardstick to measure the available energy or protein from different forages. At first, dairy cows were used at Middleburg only to evaluate pasture species, mixtures, and management programs. Later, more emphasis was placed on dry lot feeding; thus, the herd has been used to evaluate silages. Dairy calves and heifers are also used to determine the suitability of forages.

Experiments with corn silage at Middleburg have given convincing information on the proper stage of maturity for harvesting. Guidelines have been obtained for using urea as a protein substitute to supplement corn silage rations or to be added at ensiling time. Recent work has stressed the using of corn silage for its high energy value as a feed. These studies show large economical advantages for feeding either (1) urea ensiled with corn when supplemented with limited grain or (2) corn silage free choice when supplemented with a limited amount of oil meal to meet the protein needs.

Productive efficiency on most dairy farms could be increased with double cropping systems to get higher yields per acre. Cereal crops such as rye, barley, and wheat may give highly palatable and nutritious ensiling crops early enough to be followed by corn or sorghums. Milk production investigations of lactating cows fed cereal crop silages harvested at different stages of maturity have just been started at Middleburg.

Forage evaluation with dairy cows shows that high milk production and body weight increases are strongly influenced by the amount of feed eaten, its energy value as shown by digestibility, and a balance of feed nutrients, especially protein. The daily milk production per cow is based on four percent fat-corrected milk in all cases.



A – NURSING FENCE LINE
B – NURSING RAMP
C – PASSING LANE
D – ENTRANCE OR EXIT TO NURSING RAMP
E – CALF LOT
F – BUILDING FOR FEEDING CALVES
G – FROSTPROOF WATERER
H – ANTI-MOTHERING BARRIERS
I – ANTI-WEANING BARRIERS
J – COW FEEDER
K – WATERER FOR COWS
L – LOAFING AREA FOR COWS

FIGURE 19. Plan for fence-line nursing.

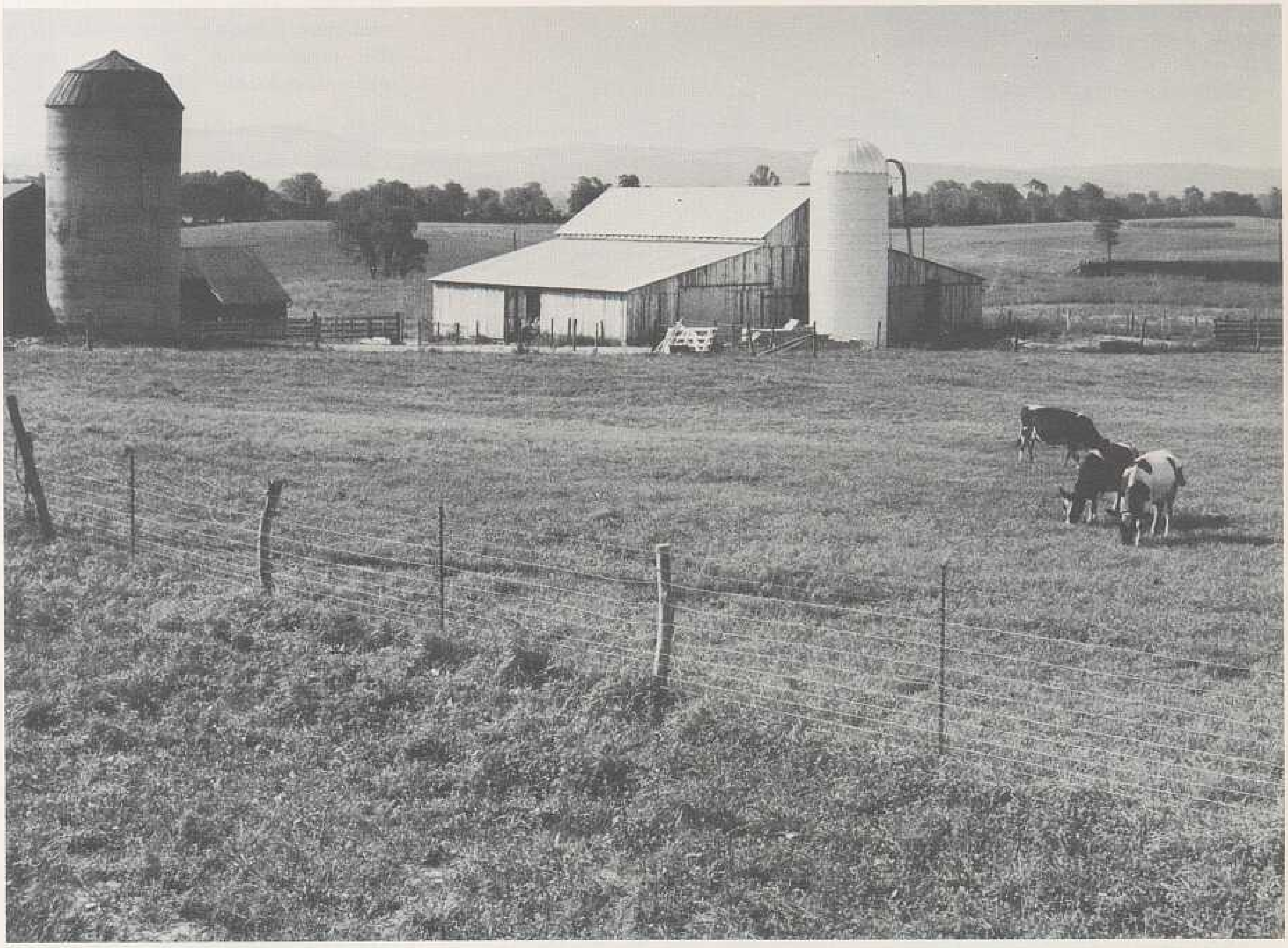
Corn Silage at Two Stages of Maturity

For two years an early maturing corn hybrid (VPI 426) with a high ear-to-plant ratio was harvested in the milk stage (22 percent dry matter) and later when the grain was well dented (32 percent dry matter). Silage dry matter production per acre was increased more than 50 percent and grain yields were increased more than five fold by delaying of harvesting (Table 30). As corn matured from milk to dent stage, the proportion of the total dry matter made up by ears increased from 27 to 51 percent. This caused the percent dry matter of the silage to increase. The starchy materials (nitrogen-free extract) and energy value (total digestible nutrients) increased with advancing maturity of plants while the percent crude fiber decreased.

Lactating cows were used to compare the corn silages at two stages of maturity. Milk production is shown graphically in Figure 20. Cows fed milk-stage corn silage produced less milk than those fed dent-stage silage. Differences became large during the course of the experiment. Cows ate more dent stage corn silage (2.38 pounds dry silage per 100 pounds bodyweight) than milk stage (only 1.51 pounds of dry silage per 100 pounds). Given a free choice of both silages, the cows ate 10 times more of the dent stage than of the milk stage silage.

Urea in Corn Silage Rations

Since urea is economical, it is logical to use it to correct the protein shortage of corn silage. Lactating dairy cows were used to find the merits of

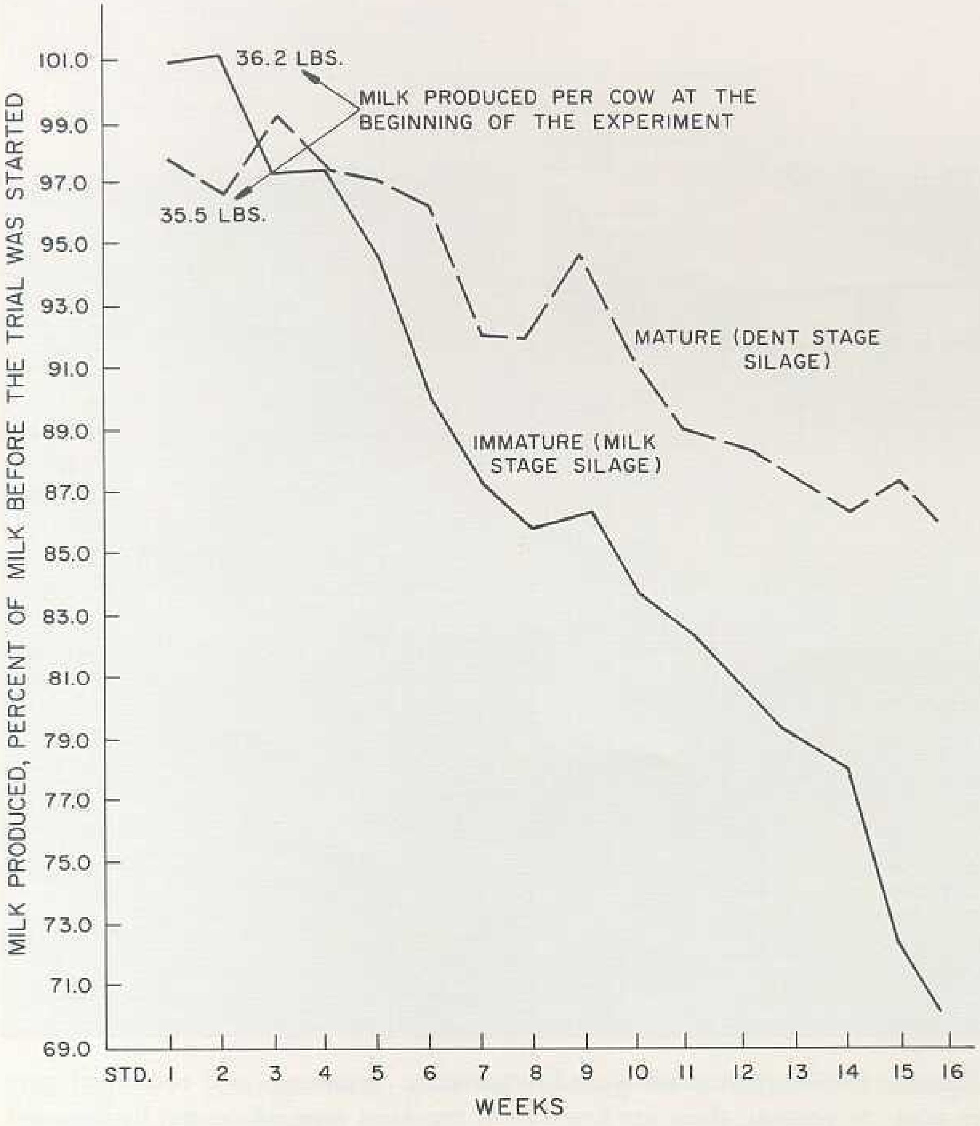


CONTINUOUS VS. ROTATIONAL: Pastures in foreground were used to compare continuous and rotational grazing on milk production per cow and per acre. At present, there are five silos at the dairy research center, background.

TABLE 30. Effect of maturity of corn on dry matter yield, energy value, and chemical composition of corn silage, two year average.

	Maturity of Corn Silage	
	Milk Stage	Dent Stage
30% dry matter silage per acre	18.0 tons	24.4 tons
Grain (15.5% moisture) per acre	25 bu.	132 bu.
Ears:		
% of total plant dry matter	27.2%	51.2%
Dry matter content, %	25.1%	51.1%
Proximate analysis:		
Crude protein	9.1%	8.1%
Ether extract	1.8%	2.6%
Nitrogen-free extract	52.6%	62.6%
Crude fiber	32.2%	23.0%
Total digestible nutrients	67.0%	70.2%

FIGURE 20. The daily milk production for cows was very satisfactory but much better for the mature corn silage.



supplementing corn silage (30.8 percent dry matter) with equal protein from the following sources: (1) a dairy concentrate (16 percent crude protein) fed at one pound/3.5 pounds milk; (2) cottonseed meal; (3) cottonseed meal plus urea on a 1:1 protein ratio; and (4) urea. Urea was mixed with the silage just prior to feeding.

As shown in Table 31, milk yields and silage intake per cow were markedly reduced and weight losses incurred when corn silage was supplemented with only urea. The other treatments gave similar milk yields and similar amounts of total dry matter eaten. These findings suggest that urea may substitute for up to ½ of the supplemental oil meal protein without reducing milk production.

Corn Silage Made with Urea

It was thought that adding urea to corn silage when ensiled might overcome problems of intake observed in the previous studies. Therefore, for two years urea was added at the rate of zero, 10, and 20 pounds per ton of 36 percent dry matter corn silage. Crude protein was increased on a dry basis from 9.3 percent without urea to 12.3 and 16.5 percent for the silages with 10 and 20 pounds urea per ton. The three silages were fed to lactating dairy cows as a part of the following rations: (1) corn silage (without urea) plus an 18 percent protein concentrate @ 1:3 (one pound for each three pounds of four percent fat-corrected milk); (2) corn silage plus cottonseed meal (41 percent protein) @ 1:9; (3) corn silage ensiled with 10 pounds urea per ton plus cottonseed meal and ground shelled corn @ 1:9; and (4) corn silage with 20 pounds urea per ton plus ground shelled corn and cottonseed meal @ 1:9. The cows were fed all the corn silage they would eat. The concentrates were individually fed twice daily and the amount fed was reduced two percent per week. Notice that concentrate feeding was very low except for Treatment 1.

The daily rations and amounts consumed are given in Table 32. Adding urea to corn silage reduced the amount of cottonseed meal needed to meet digestible protein requirements for maintenance and milk production (Table 33). The yield of four percent fat-corrected milk per cow differed little among the treatments. However, there was a little less milk for cows fed concentrates at 1:3 (12.2 pounds daily) indicating that protein supplementation is more important than supplemental energy for maintaining milk production on high quality corn silage (Table 33). Silage dry matter consumption and daily weight gains were larger for the three groups of cows fed concentrates at 1:9 than for the liberal 1:3 rates of feeding concentrates. Feed cost per 100 pounds of four percent fat-corrected milk was 29 percent more for cows fed concentrates liberally (Ration 1) than for the average feed cost of the other three rations with low concentrate supplements (Table 33).

Urea did not appreciably reduce milk production nor silage eaten. However, dry matter intake from urea treated silages was considerably lower during the first part of the experiment, indicating that time was required for cows to adjust to the urea in the silage, even though all cows were fed a urea concentrate for three weeks before this experiment. During the last six weeks, the cows ate more of the urea silage than silage without urea (Figure 21).

Corn Silage: Adequate Energy Feed for Dairy Cows

In summarizing several corn silage experiments at Middleburg, it became apparent that supplementation with digestible protein in the form of cottonseed meal caused cows to give a little more milk than did liberal supplementation with an 18 percent protein concentrate (Table 34). Cows fed low amounts of cottonseed meal (4.25 pounds/day) consumed 19 percent more silage than those fed liberal amounts of concentrates. This additional silage intake by the former group caused near equal energy feed intake, amounting to about 25 percent savings in feed cost per 100 pounds of milk.

The liveweight gains were similar for the two treatments (Table 34). This research with quality corn silage shows that high levels of milk production may be maintained by supplementing with low rates of oil meals that furnish protein and energy.

Corn Silage Compared with a Sorghum-Sudan Hybrid

Sorghum-sudan hybrids are comparatively drought tolerant and moder-

TABLE 31. Effects of various supplements to corn silage rations on milk yields, dry matter intake, and bodyweight changes.[a]

	Rations—Corn silage fed free choice			
	A	B	C	D
Milk 4% FCM (lbs.)	16% Conc. @ 1:3.5	Cottonseed meal (CSM)	Equal protein from CSM & Urea	Urea
Milk per cow daily for rations, lbs.	31.7	33.2	33.6	23.6
Dry Matter Intake (Percent of bodyweight)				
Silage	1.87	2.17	2.39	1.88
Concentrate	0.68	0.28	0.15	—
TOTAL	2.55	2.45	2.54	1.88
Average Daily Weight Changes Lbs.	+1.10	+0.68	−0.53	−0.46

[a] There were four cows per treatment for 112 days.

TABLE 32. Description of rations and daily consumption per cow.

	Rations			
	1	2	3	4
	Corn silage—no urea		Corn silage	Corn silage
	Plus an 18% protein conc.	plus cottonseed meal	10 lbs. urea per ton	20 lbs. urea per ton
Corn silage eaten daily (36% dry matter)	79.5 lbs.	92.7 lbs.	90.3 lbs.	88.3 lbs.
Concentrates [a]				
Rate Fed (feed: milk ratio)	1:3	1:9	1:9	1:9
Consumed				
18% protein conc.	12.2 lbs.	—	—	—
Cottonseed meal	—	4.1 lb.	2.2 lb.	0.9 lb.
Ground shelled corn	—	—	1.9 lb.	3.3 lb.

TABLE 33. Comparison of milk production, dry matter intake, and weight changes of cows on corn silage rations during two years.[a]

	Rations			
	1	2	3	4
	Corn silage—no urea		Corn silage	Corn silage
	Plus an 18% protein conc.	plus cottonseed meal	10 lbs. urea per ton	20 lbs. urea per ton
Milk daily per cow, lbs.	40.4	42.8	41.7	41.2
Dry matter eaten per 100 lbs. bodyweight				
Silage	2.44	2.82	2.77	2.76
Conc.	0.85	0.30	0.30	0.30
TOTAL	3.29	3.12	3.07	3.06
Daily gains, lb.	+0.90	+0.96	+1.25	+0.94
Feed Cost per 100 lbs. 4% FCM	2.08	1.62	1.60	1.58

[a] Summary for 16 weeks, 12 cows per group. Initial milk production averaged 43.6 pounds daily.

TABLE 34. Effect of supplementation of corn silages on milk production and silage intake.

	Ration A	Ration B
	Corn Silage Fed Free Choice	
	Cottonseed Meal 41% crude protein	Dairy concentrate 16-18% crude protein
Daily concentrate per cow, lb.		
Cottonseed meal	4.25 lbs.	3.3 lbs.
Shelled corn	——	9.2 lbs.
Total	4.25 lbs.	12.5 lbs.
Milk daily per cow, lbs.		
Standardization (before the experiment)	43.0 lbs	43.3 lbs.
Milk for the rations	39.4 lbs.	36.4 lbs.
Rations/standardization x 100	91.6%	85.4%
Silage as dry matter consumed per 100 lbs. bodyweight	2.70 lbs.	2.27 lbs.
Average daily gain, lbs.	+0.89 lbs.	+0.84 lbs.

TABLE 35. Sorghum-sudan hybrid compared with corn as silage for milk production.[a]

	Corn Silage Free Choice		Sorghum-Sudan Silage Free Choice	
	Cottonseed Meal 41% Protein	Concentrate 16% Protein	Cottonseed Meal + Shelled Corn	Concentrate 16% Protein
Milk per cow daily, lbs.	36.8 lbs.	33.5 lbs.	32.2 lbs.	37.2 lbs.
Dry Matter Intake Lbs. per 100 Lbs. of liveweight				
From Silage	2.73	2.28	2.60	2.12
From Concentrate[b]	0.29	0.95	0.27	0.98
Total	3.02 lbs.	3.23 lbs.	2.87 lbs.	3.10 lbs.
Daily Liveweight Gains, Lbs.	2.0	2.1	1.0	1.1

[a]8 cows per treatment group for 56 days.

[b]Cottonseed meal was fed to furnish 10% excess digestible protein in rations. Cows fed sorghum-sudan silage required less cotton-seed meal than the comparable group fed corn silage, therefore, some additional ground shelled corn was fed to the former group. The 16% C. P. concentrate was fed at the rate of 1 lb. for each 3 lbs. of 4% fat-corrected milk.

TABLE 36. The value of early and late corn hybrids and stage of maturity of a sorghum-sudan hybrid harvested for silage on 4% fat-corrected milk production, dry matter intake and weight gains.[a]

	Corn Silage Medium Maturing	Late Maturing	Sorghum-Sudan Silage Late-Cut	Early-Cut
Milk per cow daily, lbs.				
Standardization before starting the experiment	46.6	46.8	43.8	44.0
For rations	38.7	39.2	32.1	35.2
Ration/standardization x 100	83.0%	83.8%	73.3%	80.0%
Dry Matter Intake Per 100 lb. Liveweight				
Silage	2.54	2.38	1.96	2.25
Concentrate	0.72	0.74	0.69	0.74
Total	3.26	3.12	2.65	2.99
Daily Gains per Cow, lbs.	1.22	0.63	0.05	0.55
Dry Matter Digestibility, %	66.0	63.0	56.2	66.0

[a]6 cows per group for 105 days.

ately high yielding, and are, therefore, used for silage by many farmers. In this experiment sorghum-sudan harvested for silage in a young leafy stage of growth when heads were just emerging (30-40 inches high) was wilted to 40 percent dry matter, then ensiled. This was compared to hard-dent corn silage (39 percent dry matter). Treatments and results are further described in Table 35. As noted, the cows produced more milk from corn silage supplemented with a little cottonseed meal than with liberal feeding of a 16 percent protein concentrate. With the sorghum silage, more milk was produced with the 16 percent protein concentrate. The corn silage fed cows gained two pounds daily, nearly twice as much as the cows on sorghum-sudan silage. These results point out the high energy value of corn silage and its need for adequate protein supplementation. With the sorghum-sudan both protein and energy supplements were needed.

Later, sorghum-sudan, harvested at two stages of maturity, was compared for silage with a medium and late maturing corn. The early-cut sorghum-sudan silage, the two corn silages and the concentrates fed were similar to those in the previous experiment. The late-cut sorghum-sudan silage was harvested when plants were fully headed, leaf tips brown, at an average height of 7 feet. The rations and results are described in Table 36. Corn silage was definitely better for milk production than the sorghum-sudan silage at either stage of maturity. Silage dry matter intakes, liveweight gains and dry matter digestibilities were lower for the sorghum-sudan silage than for corn silage. The feeding value and intake was lower for the late maturing than for the medium maturing corn although milk production for the two were similar.

Corn Silage for Dairy Calves

In this experiment, corn silage (31 percent dry matter) was fed free choice to young dairy calves with low amounts of either concentrates or hay (Table 37). Practically all of the concentrates fed were consumed, but only about 60 percent of the hay was eaten. Calves fed three pounds of starter with corn silage gained at a desirable rate of 1.60 pounds daily; the calf gains for the other treatments were too low.

Later a second experiment was planned with corn silage and supplements as compared with hay and supplements (Table 38). Here the calves were a month older and 32 pounds heavier than in the first experiment. The calves fed corn silage free choice and 1.1 pounds of cottonseed meal daily gained 1.69 pounds per day as compared to 1.44 pounds daily when fed a urea-ground shelled corn mixture. The gains for calves fed hay and 18 percent protein concentrate were only 1.18 pounds daily. Dry matter intake per calf was similar for all treatments; however, the amount of dry matter used per pound of gain was lowest for the corn silage rations, especially with cottonseed meal. Feed costs per pound of gain are related to

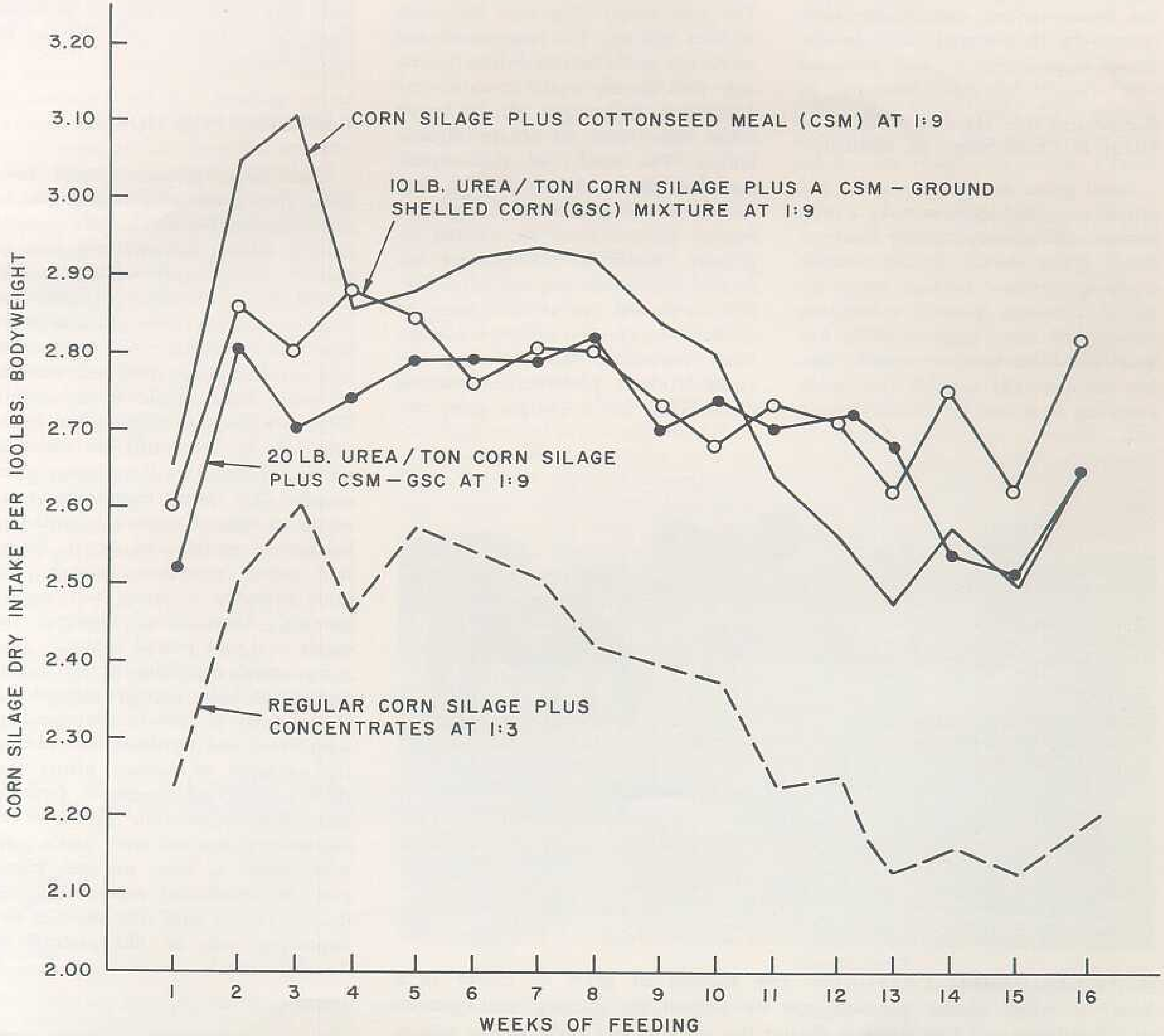


FIGURE 21. High concentrate feeding reduced corn silage consumption. Urea corn silages were eaten about as well as corn silage without urea after the cows became adjusted to it.

rate and efficiency of gain; costs were about 80 percent higher for the hay-grain group.

The calves fed corn silage and cottonseed meal in the first experiment gained only 1.24 pounds as compared with 1.69 pounds daily in the second experiment. The primary reason for this difference in rate of gain can be attributed to higher consumption of the more mature corn silage (dry matter 36-38 percent) used in the second experiment.

Barley and Rye Harvested for Silage at Three Stages of Maturity

Small grains are widely adapted and can be depended upon to make a crop because soil moisture is rarely limiting. Small grains should fit into double cropping systems because early removal as silage permits subsequent planting of corn, sorghum-sudan hybrids and other summer annuals. Rye may be especially suitable for double cropping as it can be planted late in autumn, is hardy, and grows earlier in the spring than barley.

An experiment was conducted to determine differences in feeding value and dry matter consumption of barley and rye each harvested at boot, full bloom, and soft dough stages of growth. The first two stages of maturity were wilted in an attempt to obtain a 35 percent dry matter silage. The soft dough silage was harvested without wilting. The silages were fed to Angus and Holstein heifers as the only feed for six weeks to obtain intake and liveweight data. Angus steers were used to obtain digestibilities. The results of this experiment are presented in Table 39. Due to harvesting difficulties, silage dry matter differed from the desired 35 percent. Yields of dry matter increased with advancing maturity. Barley out-yielded rye at each stage of growth; the rye, however, was planted late (November 3), reducing the yields. Animal performance (intake, digestibility, and liveweight gain) was also lower for rye than barley at each stage of growth. Performance from rye decreased with advancing maturity while that for barley was highest at boot, lowest at bloom, and intermediate at soft dough. That soft dough barley is superior to full bloom, is consistent with results obtained with lactating cows at Middleburg.

Current varieties of small grain yield only about 50 percent as much silage dry matter as corn, but can be useful sources of forage.

PASTURES FOR HORSES

Good horse pastures should have dense grass-clover sods of young leafy short growth for the longest possible grazing season. Accumulated autumn pasture along with winter growth should be reasonably palatable for winter grazing. Horse pastures must have dense persistent sods to furnish both excellent nutrition and exercise all year. They should be reasonably large to encourage running and minimize injuries. Separating the watering places and shelters will encourage more exercise. It is almost imperative to use cattle to control growth to obtain a balance of grasses and clover, maintain young nutritious growth, and limit extremes in over- and undergrazing. Substituting mowing for cattle is a poor second choice.

Successful establishment and maintenance of horse pastures depends on the interplay of climatic environments with limed and fertilized soils and on the adaption of pasture plants and their grazing managements. Grazing and adaptive research principles at Middleburg obtained with cattle generally apply to horse pastures. However, we conducted experiments and demonstrations with new seedings and improving sods on old pastures at Rokeby Farm.[1]

THOROUGHBRED PASTURES: The amount of grass or clover in a bluegrass-white clover pastures can be altered by grazing management and fertilization. Close grazing during the autumn and early spring season favors clover, lax grazing favors grass. This is a Rokeby Farm pasture with good clover growth during the summer.

[1]The excellent cooperaton of Garland Moon, Farm manager, George Comer, stable manager, and Paul Mellon, owner, is gratefully acknowledged.

TABLE 37. Effect of supplementation of corn silage on calf gains.[a]

	Corn Silage (30.6% Dry Matter) Free Choice		
	Cottonseed Meal 41% C.P. 1#/Day	Calf Starter 25% C.P. 3#/Day	Alf-Orch. Hay 17.2% C.P. 4½#/Day
Starting Age, Days	93	85	90
Initial Weight, lbs.	212	203	228
Average Daily Gains, Lbs.	1.24	1.60	1.11
Avg. Daily Dry Matter Intake (Lbs.)			
Silage	5.47	4.12	4.95
Supplement[b]	.85	2.64	1.47
Total	6.32	6.76	6.42
Dry Matter/Lb. Gain	5.08	4.20	5.76

[a]Three Holstein heifer calves per treatment for 124 days.

[b]Either cottonseed meal, calf starter or alfalfa-orchardgrass hay.

TABLE 38. Effect of hay-grain vs corn silage plus cottonseed meal or urea-shelled corn rations on efficient economy and rate of dairy calf gains.[a]

	Alf-Orchardgrass Hay Free Choice	Corn Silage (36-38% D.M.) Free Choice	
	Concentrate 18% C.P. 1.1#/Day	Cottonseed Meal 41% C.P. 1.1#/Day	.13 Lb. Urea .97 Lb. Sh. Corn
Starting Age, Days	120	122	117
Initial Weight, Lbs.	242	253	245
Average Daily Gains, Lb.	1.18	1.69	1.44
Average Daily Dry Matter Intake Lbs.			
Forage[b]	7.30	7.25	6.90
Concentrate	.97	1.01	.97
Total	8.27	8.26	7.87
Dry Matter/Lb. Gain	6.88	4.91	5.50
Feed Cost/Lb. Gain[c]			
Forage	.121	.054	.060
Concentrate	.029	.033	.023
Total	$.150	$.087	$.083

[a]11 calves on hay-grain and 12 calves on each of the silage rations for 84 days.

[b]Hay fed at 10% and silage at 5% in excess of consumption.

[c]Corn silage $10/ton of 40% DM, hay $35/ton, shelled corn $55/ton, 18% C.P concentrate $72/ton and urea $110/ton.

New Seedings

Establishing pastures begins with soil tests, and then applying lime and fertilizer as needed. Seedbeds may be prepared by repeated disking or by plowing and disking to destroy existing vegetation. Disking leaves areas rather rough as compared to plowing and disking. Seedings may be made in early spring or late August to early September after the tilled soils have been firmed by a shower. Covering the seed ¼ inch by rolling improves germination and speeds up establishment.

We made an experiment with 40 mixtures within a newly seeded horse pasture at Rokeby Farm where all mixtures were grazed by thoroughbreds. Varieties of bluegrass, fine leaved fescue, tall fescue, brome, orchard, timothy, ryegrass, and white clover from the United States and abroad were used in the experiment. Grass species and varieties were evaluated with white clover mixtures and the white clover varieties were seeded in bluegrass-orchardgrass mixtures.

American and British timothy varieties were preferred over other grasses by horses, but summer growth was poor and all varieties were short-lived under grazing. Kentucky 31 fescue, a tall fescue, was very coarse and horses generally refused to graze it. Because of its wide moisture and temperature adaptation, along with not being grazed, it crowded out clovers and other grasses. Strains of meadow fescue, especially British ones, were severely damaged by rust, but palatable as compared with Ky. 31 fescue. Creeping red fescue and redtop grasses produced dense sods at first, but these grasses were not suitable because the horses avoided grazing them and the sods became sparse with age. Ryegrass was very palatable, but it is objectionable in mixtures; ryegrasses germinate quickly and the vigorous seedlings, because of light competition, crowd out the slower growing desirable seedlings. This explains why ryegrass is aggressive toward bluegrass and other plants. Seven weeks after sowing, ryegrass seedlings were 20 times heavier than bluegrass seedlings. Bromegrass did not produce a satisfactory sod; it was attacked by several diseases.

Orchard and bluegrasses were the best grasses for horse pastures. Due to slow germination and seedling growth bluegrass is a slow starter, but the sod keeps improving under continuous grazing. Orchardgrass was suppressed under heavy continuous grazing. However, orchardgrass was a very desirable component with bluegrass since for the first seven weeks its seedlings grew seven times faster than bluegrass. Thus, orchardgrass shortened the period of sod establishment and aided in competing against weedy invaders; it did not crowd out bluegrass under low seeding rates and early grazing. The Virginia strains of orchardgrass were more vigorous and lived longer than strains introduced from the United Kingdom. The United Kingdom varieties, however, were small and had desirable semi-prostrate habits of growth. The orchardgrasses maintained in a leafy condition were grazed as readily as bluegrass.

Not one of the eleven varieties of white and ladino clovers was outstanding in adaptation. Common white clovers were generally better than special strains or introductions from abroad. The types from the more southern seed producing areas such as Louisiana white clover produced more seed. Reseeding white clovers while they are pastured is desirable, for new stands develop from volunteer seed when old clover plants die. Ladino clover started faster than white clover, but this tall clover is aggressive toward bluegrass and later failed to survive in bluegrass sods under close grazing. It appears to be more susceptible to frost damage than white clover. Such frosted growth may cause nutritional problems with horses.

Based on this mixture experiment and observations elsewhere, an ideal mixture for cooler bluegrass regions of Virginia is:

Kentcky bluegrass, 10 to 15 lbs. per acre
Virginia or Potomac orchardgrass, 3 to 5 lbs. per acre
White clover, 1 to 3 lbs. per acre

Because orchardgrass starts quickly, this mixture should be grazed down at a 4-inch height to reduce light competition against white clover and bluegrass in the sod canopy. With years, under continuous grazing, this mixture becomes mostly bluegrass with white clover. This simple 2-grass-white clover mixture furnished a better sod and grass-clover balance than complex mixtures with five species. Desirable permanent plants were generally crowded out by the aggressive plants in complex mixtures.

Degenerated Pastures

In regions where bluegrass and white clover are adapted, weedy sods with sparse stands of desirable grasses and clover can be easily improved without tillage and reseeding. Encroachment of grass and clover and competition against weeds is stimulated by liming and fertilizing; weeds thrive in highly acid and infertile soils. It is ideal to begin with improved fertility in September; after summer weeds grow slowly because of cool temperatures. Bluegrass, with its underground rootstocks, spreads rapidly during late autumn and grows ahead of most weeds the next spring, especially when nitrogen is included in the fertilizer. The creeping aboveground stems (stolons) of white clover also spread rapidly, encroaching sparse sod areas when lime, phosphorus, and potash in soils are readily available. Encroachment of bluegrass and clover is stimulated by close grazing. Many fertilized weeds when grazed closely are quite palatable and grazed readily. Weeds, like pasture plants, are grazed more readily in young leafy than in stemmy growth stages. Also, with reasonably heavy grazing, the unpalatable weeds must be grazed along with the desirable grasses and clovers.

For sods with very poor stands of grass and clover and pastures grazed very closely during fall and winter a grass-clover mixture drilled into sod during early spring has given good stands and quick sod improvement. It is best to mix the grass-clover mixture with triple superphosphate at 100 to 200 lbs. per acre, drilled into the soil at an average depth of ½ inch. Seedling grasses and legumes are stimulated by the contact phosphorus fertilizer. Caution—most forms of phosphate, other than triple superphosphate, burn seedlings.

Grassy sods with clover are a frequent problem. White clover stands are vulnerable to loss because of tall grass growth and light competition during spring, as well as diseases, winter killing, and drought. The latter two are aggravated by the shallow roots of white and ladino clovers. It is easy to re-establish white clovers in grassy sods by grazing heavily all winter to thin the sod to expose much of the soil. Clover seeds in contact with phosphate, drilled into sods in mid-March, establish themselves quickly, if grazing is heavy enough to avoid severe light competition from the early erect growth of grasses.

Sod seedlings made during August and September or in late spring generally fail because the small seedling plants cannot endure the severe surface moisture competition from the established sod. Moisture competition is not likely to be serious during early spring.

It is necessary to plow or use weed herbicides when certain weed pests are present. It is rarely necessary to disk or plow to control grass-clover balance in sods.

Grass-Clover Balance in Sods

Maintaining productive sods demands adequate liming and fertilization, good rainfall distribution, and grazing management. Ideally, the sod should have around 25% clover; more clover may cause "slobbers." Such an exact clover content cannot be maintained. The amount of clover in sods is naturally cyclic; favorable moisture stimulates clover more than grass. Excellent clover seasons add much soil nitrogen; thus stimulated grass growth the next year becomes competitive, causing clover to decline.

Nitrogen fertilizer is an aid in shifting clover sods to grassy ones; lime and fertilizer elements other than nitrogen encourage clover. However, grazing management is very important in controlling the grass-clover balance.

Cattle must be available to control pasture growth on thoroughbred farms where stocking rates with horses are necessarily light. At Rokeby Farms, we have been successful in shifting grassy pastures to more white clover and clover pastures to more grass without rotational grazing. We have not found it necessary to plow and reseed to maintain a grass-clover balance.

Bluegrass grows at lower temperatures than white clover; this is why bluegrass grows earlier and later in the season than white clover. Close grazing all year, but especially during the autumn and early spring seasons, reduces the light competition from bluegrass and increases clover. Volunteer clover seeds in soils germinate in autumn and spring; hence, short sods aid clover seedling survival. Continuous very close grazing, with favorable summer moisture, further retards bluegrass, causing a clovery sod. Bluegrass leaves grow erect, those of clover are horizontal on short stems; thus, under close grazing, the clover shades bluegrass causing a shift to more clover. The temperature of soils and basal plant parts increases with very close grazing because the insulating effect of sods is lost. High summer temperatures retard bluegrass more than clover.

If the pasture has too much clover, cattle should be withheld during early spring; the early erect bluegrass growth then shades white clover, causing it to decline due to low light intensity. Early spring nitrogen fertilizer with light grazing would make bluegrass even more competitive. Allowing bluegrass in white clover pastures to produce seed or cutting for hay practically exterminates clover; with tall heading bluegrass, the light intensity is extremely low at the canopy level of white clover leaves.

TABLE 39. Effect of stage of maturity of rye and barley on silage yield, quality, intake and animal gain.[a]

	Barley			Rye		
Dry Matter	Boot	Bloom	Soft Dough	Boot	Bloom	Soft Dough
at Harvest, %	21.2	26.8	32.2	19.8	25.6	36.2
as Silage, %	32.8	32.7	29.7	27.2	43.0	42.9
Yield/Acre, Lbs.	4200	6628	7635	2440	3990	6700
Intake/100# BW	1.85	1.63	1.86	1.57	1.35	1.27
Digestibility	68.7	59.8	59.3	65.9	59.0	55.2
Daily Weight Change, Lbs.	+1.23	+0.18	+0.46	+0.05	−0.16	−0.24

[a]Animal values are averages per head for 6 weeks. Four yearling Angus, two 10 month and two 22 month old Holstein heifers per silage.

A 2-inch grazed sod residue favors fast grass regrowth; with a short 1-inch sod or cluster, clover dominance is favored. After grazing, new clover leaflets develop from buds on runners at the soil surface; thus, the taller sod residues slow down clover regrowth. Sickle-bar mowers normally leave a 3-inch sod; hence, mowing is not close enough to aid in grass control for clover regeneration.

When the pasture is under continuous grazing and light stocking with thoroughbreds, the horses keep grazing the short pasture closer; because it is highly nutritious—high in protein, minerals, and digestibility as compared with taller ungrazed areas. Without cattle, the areas grazed closely become clovery and during drought the clover may die leaving bare soil. *In the same pasture*, most of the area is grazed lightly or not grazed at all, causing a loss of clover stands. Tall or headed grass causes a utilization problem all year, and the spongy frosted unutilized growth is not readily grazed and prevents clover growth the following year.

When such extreme over-and undergrazing is noticed in early spring, pastures should be stocked very heavily with cattle up to 20 head per acre. Cattle also prefer the short pasture, so stocking must be so heavy to force cattle to graze the tall growth to a short residue. The flush spring growth occurs yearly; thus, cattle should be used during the early spring to keep pastures grazed closely to avoid seedhead development. The cattle may then be withdrawn to allow reserve pasture growth before the warm summer months.

Rotted cow manure spread over closely grazed pasture areas gives some relief from close grazing by horses.

Rotation of Pastures

The spotted over- and undergrazing made by horses cannot be fully overcome by adding and withdrawing cattle. It is best to provide enough pasture fields so a pasture can be rested from horse grazing for a period of several months yearly. Two pastures for a given group of horses are adequate, the rested pastures should be grazed intermittently with cattle for several months or until the grass-clover balance and sod is uniformly grazed. It is best to stock heavy for short periods, the cattle are then withdrawn.

ADAPTIVE RESEARCH WITH GRASSES AND LEGUMES

Virginia is well suited for growing annual and perennial plants for silage, hay, and grazing. The steep and rolling topography and soil conditions where tillage is impractical, make it necessary to use perennial sod crops. For much of the land in Virginia there is no alternative to pasture; hence, such land areas are ideal for raising livestock and horses.

In our work, grasses and legumes grown alone and in mixtures were studied under different soils, fertilization, and cutting and grazing intensities. Single species and mixtures were studied with seeding methods and with spring and late summer seedings. These seedings were examined for total and seasonal dry matter yields; grasses, legumes, and weeds in yields and sods; productive life of stands; quality of the hay or pasturage and problems with weeds, diseases, and insects. Some of our findings are summarized here.

Yields of Perennials and Annuals

Perennial grasses and legumes in mixtures grow over a longer season than warm season annuals such as corn and sudangrass. However, the yields of dry matter from perennials are lower than for such adapted annuals. There is a critical need for developing higher yielding perennial plants that produce a more uniform yield over a longer season.

The low yields are attributed to the summer slump apparently caused by shallow roots and insufficient water and temperatures too high for high rates of photosynthesis. The taller deeper rooted plants such as alfalfa produce more dry matter per acre than the short plants with shallow roots such as white clover, bluegrass, and annual lespedeza.

Advantages of Mixtures

It is often necessary to use mixtures for stable long-lasting pasture sods that tolerate animal treading. Grass-legume mixtures improve quality e.g. grazing animals produce more milk or meat from mixed grasses and legumes than from grasses alone. Legumes alone are not ideal for grazing because the sods are not persistent. Dense grassy sods insulate the soil to moderate sod and soil temperatures in summer and winter. Such temperature moderations are protective to white and ladino clovers with shoot and root buds in stolons at the soil surface. During wet winters with high soil moisture, there is much less heaving (plants lifted up by ice formation under the soil surface) of alfalfa and clover in grass sods because of more moderate temperatures. Grasses shade soils more effectively than legumes; thus, grass-legume mixtures are less weedy than legumes. The grass sods moderate temperatures and offer light competition because the leaves and basal tissues remain greener and give better soil cover than legumes.

Because nitrogen is fixed in nodules on legume roots, pasture, hay, and silage is produced more cheaply from legume-grass mixtures than from grasses alone. Cool season grasses such as tall fescue and orchardgrass with liberal nitrogen fertilization produce about as much dry matter as high yielding legumes. However, nitrogen increases the cost of growing grasses as responses per unit of nitrogen are not high enough. Higher yielding grasses would make it practical to use nitrogen fertilizer. For example, 150 pounds of nitrogen (N) per acre will produce around eight tons of dry matter for a corn silage crop, about 2.5 times more than for perennial grasses. Note that yields of grasses averaged only 5700 pounds per acre with 150 pounds N nitrogen per acre; there was only a 32 percent increase in yield when the rate of N was doubled —(Table 40).

An adapted high yielding legume such as red clover or alfalfa will usually produce yields similar to the combined yield of the legume and grass in mixtures. A grass in a mixture with a legume is desirable because legumes are more vulnerable to stand losses than grasses; thus, grasses usually increase the productive life of stands. Mixtures are desirable because the plants in mixtures compensate for each other to maintain yields; also, mixtures are suitable for flexible utilization—hay, silage, and grazing.

Physiological and nutritional problems with ruminants are usually avoided by using mixtures. For example, the incidence of bloat caused by legumes is reduced by a grass-legume sod. Magnesium deficiency or nitrate toxicity sometimes occurring with liberal nitrogen fertilization of grasses are less apt to occur when clover is used in mixtures.

Disadvantages of Mixtures

Although it is generally desirable or necessary to use grass-legume mixtures, this creates establishment and maintenance problems because of severe competition for light, nutrients, and moisture. It is simpler to manage pure stands of grasses or legumes than mixtures, and it is much easier to handle nitrogen fertilized grasses than grass-legume sods. At times, plants in a sod mutually benefit each other; but most of the time they are aggressively competitive and the sod shifts to mostly clover or grass. Such changes in plant populations in a sod occur because the rate of growth or persistence of species varies with the soil, climatic, and biotic factors that affect growth. The plants best adapted to a given set of imposed and natural environmental conditions grow vigorously and crowd out the slower growing plants. Those that live and produce the most forage during and after establishment are best suited to the growing conditions.

Because the severe competition among plants, the mixtures should be simple, no more than one or two grasses and legumes. Complex mixtures with many grasses and legumes do not give high yields; excellent early, late, and summer growth; high quality of feed; and long lived persistent stands as is often thought. The aggressive plants crowd out the less aggressive ones and the yield of a complex mixture is usually less than for one with an adaptive grass and legume.

Managing Mixtures for Yield and Quality of Feed

The perennial grass-legume plants or mixtures to use depend on soils, especially drainage, depth, and fertility along with the use—silage, hay, pasture, or combinations thereof. Lime and fertilizer practices used should give the best economic yield per unit of production; fertilizers are used to get high yields and to maintain the plants. Soils and plants influence quality, but the quality is related to the method of cutting or grazing.

With an environment for good growth, the yield, quality, and plants in the sod depend on cutting and grazing management. It is not possible to cut or graze to obtain maximum yields and quality at the same time as noted in Table 41. Frequent cutting causes young leafy growth that is high in protein, minerals, vitamins, digestibility, and palatability and low in fiber and lignin. On the other hand, with infrequent cutting where plants are allowed to grow to the bloom stage, they get stemmy and low in nutritional value and consumption. The degree of leafiness of various stages of plant growth when utilized is related to high quality (Table 41). However, the younger and leafier the growth, the lower the yields. For plants that grow to stems such as alfalfa and red clover, the best yields are obtained by allowing the plants to reach the bloom stage, but this reduces the quality of the feed.

The yield and quality must be wisely compromised. For example, much better quality can be maintained for the shorter pasture species because they can be maintained in a leafy condition as they are utilized; also, the yields stay comparatively high with frequent cutting. On the other hand, with taller growing grasses and legumes such as red clover and alfalfa, cutting six to eight times a year would give excellent leafy herbage but the yields would be low; such tall growing species cannot be harvested in a young leafy stage as the stands are lost. The cutting or grazing management of each species or mixture must be carefully manipulated to compromise between high yields and quality. In addition, the cutting and grazing management practices should be manipulated to give a desired grass-clover balance. Information on mixtures and their management has been published in other publications and made available to farmers through extension service.

Seedling Competition

When grasses or legumes are seeded alone or in mixtures, they soon compete with each other for light, mineral nutrients, and water; the species with weak seedlings then disappear from sods. Our research shows large differences in the aggressiveness of seedling plants. Some grasses and legumes grow 10 to 15 times faster than other grasses; the plants that give excellent and fastest seedling emergence and grow the fastest are aggressive toward other plants. Note the differences in seedling size in the two photographs. White clover and bluegrass grow much slower than the

TABLE 40. Yield of several grasses as affected by two rates of nitrogen per acre.

	Yield Pounds Per Acre		
	150 Pounds of Nitrogen	300 Pounds of Nitrogen	% Increase
Midland Bermuda	4400	6600	50%
Virginia Orchardgrass	5800	7400	28%
Kentucky 31 Fescue	6700	9600	43%
Reed Canary Grass (Ioreed)	6000	7200	20%
Kentucky Bluegrass	5100	6500	27%
Clair Timothy	6300	7500	19%
Average	5700	7500	32%

70 lb. K_2O and P_2O_5 were applied each year.

TABLE 41. Stages of plant growth as related to feeding value of legume-grass mixtures used for pasture, silage or hay.

	Stage of growth when cut or grazed		
	Vegetative (Pasture)	Bud or heading (Early cut)	Full bloom (Late cut)
Steminess	Low	Medium	High
Protein	High	Medium	Low
Minerals	High	Medium	Low
Digestibility of dry matter (%)	65-75	55-60	47-53
Fiber and lignification	Low	Medium	High
Palatability	High	Medium	Low
Need for concentrate supplements	Low or None	Medium	High
Kind of supplements	Energy or None	Energy	Energy and Protein
Potential Yield	Low	Med. High	Med. High

TABLE 42. Total yields per acre (12 percent moisture) of a bluegrass-white clover mixture as affected by rates and dates of nitrogen applications.

Nitrogen Pounds Per Acre	Bluegrass-White Clover 4-Year Average	% White Clover 4th Year
40 February	5900	27
40 May	5600	28
40 July	5600	33
40 August	5300	31
40 February, May, July, August	6900	1
40 February, August	6400	14
No Nitrogen	5400	39
Average	5900	

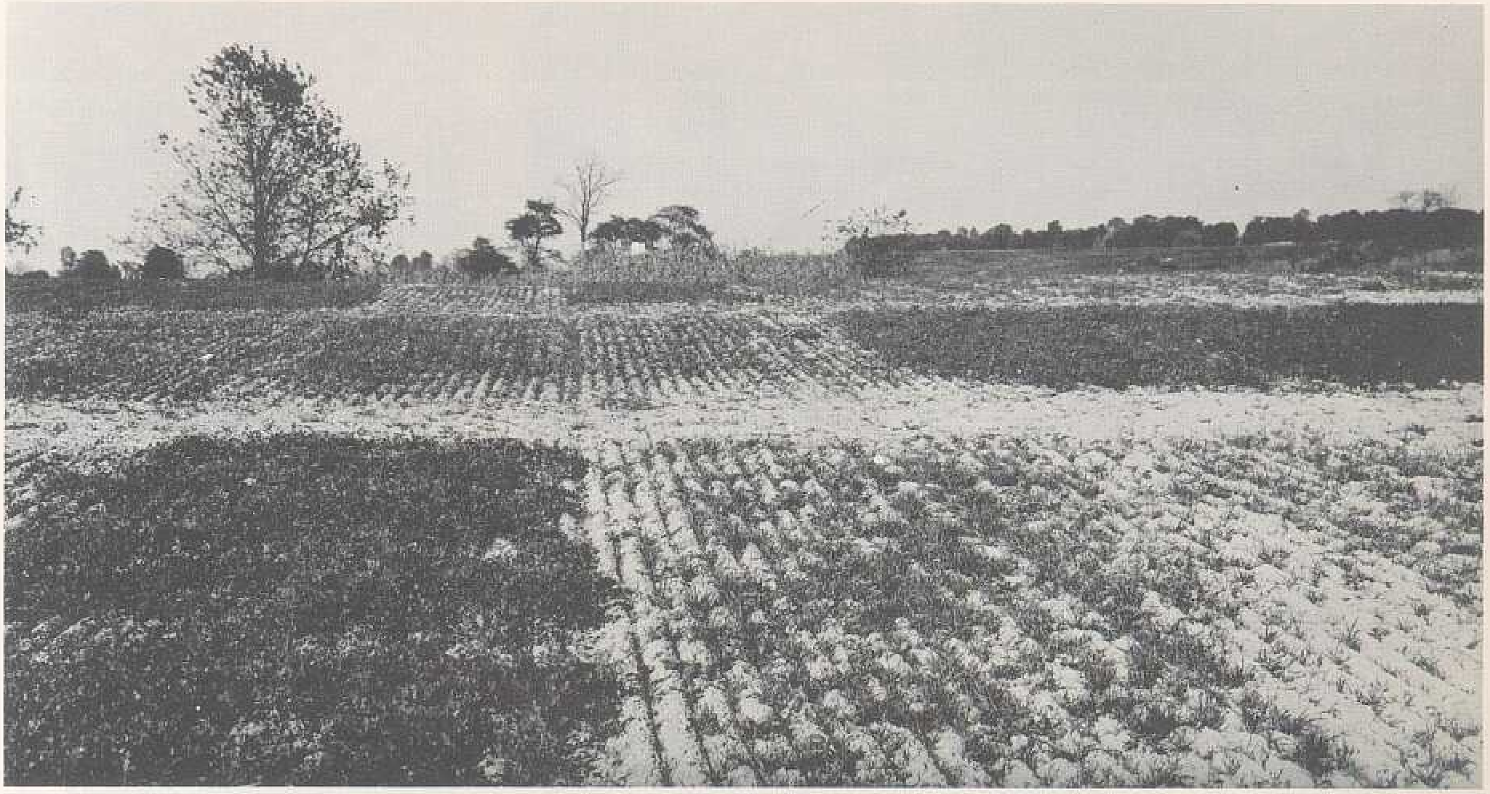
other grasses and legumes.

It is interesting to note that the aggressiveness of seedling plants differs with spring and summer sowing. Note that orchardgrass and red clover seedlings are larger than alfalfa with spring seedings, Figure 22. On the other hand, alfalfa seedlings were much larger than red clover or orchardgrass for summer sowing. All of the plants sown in August grew slower than those in March, but alfalfa was very aggressive toward red clover and orchardgrass with late summer sowings; whereas with spring sowings the other plants were aggressive toward alfalfa. It should be emphasized that the plants given in Figure 22 were grown together in a mixture.

The amount of seed that germinate and develop into healthy seedlings also influences the aggressiveness and survival in a competiitve plant community. Note in Figure 23 that red clover and orchardgrass seedling stands were poor for late summer as compared to spring sowings. For example, when alfalfa was sown at 10 pounds per acre in a mixture, there were 32 seedlings per square foot for spring as compared with 22 for summer sowing. With orchardgrass at three pounds per seed per acre, there were 20 seedlings per square foot with spring sowings as compared with only three plants per square foot with summer seeding. The stands of seedings with red clover were also poor with summer as compared with spring sowing.

The stands and seedling growth rates are very important in designing mixtures and rates of seeding. We found that red clover and orchardgrass were very aggressive toward alfalfa in spring seedings; the stand of alfalfa in the hay crop was poor when

QUALITY WITH STAGES OF GROWTH: The quality of perennial grasses and legumes depend on the stage of growth. Young growth of an alfalfa-orchardgrass mixture is leafy palatable and highly digestible. Older growth, right, gets stemmy, low in protein and minerals and is not eaten as readily. Cutting alfalfa mixtures when quality is at its best, would give low yields and cause stand losses. The first crop of an alfalfa-orchardgrass mixture should be cut when orchardgrass begins to head, thereafter when alfalfa blooms.



SEEDLING VIGOR DIFFERS: All plots were seeded at the same date in August. Right—an alfalfa orchardgrass mixture developed a stand quickly. Left—an orchardgrass-ladino clover mixture started slowly.

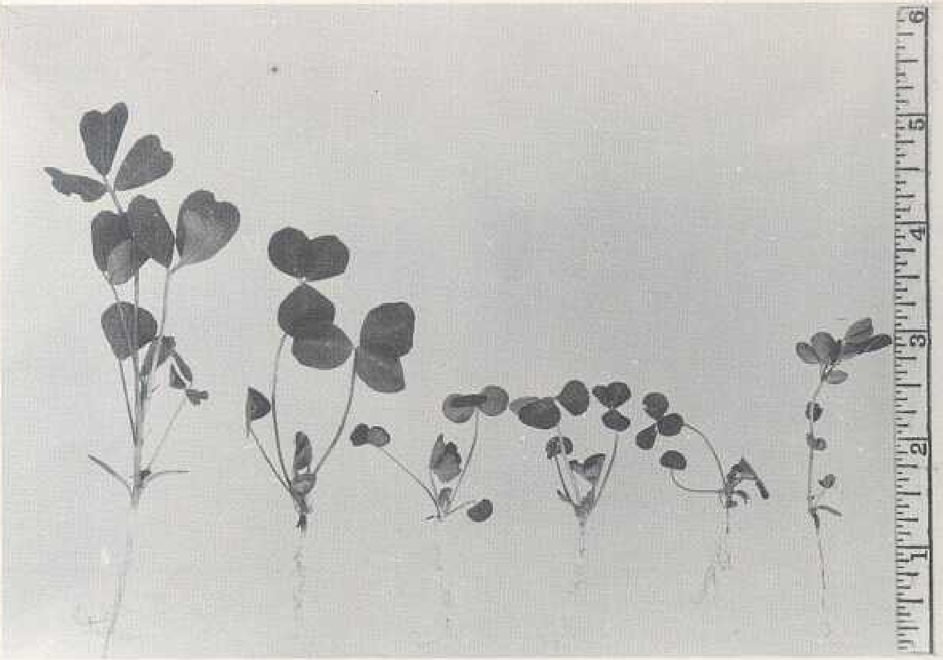
using too much red clover or orchardgrass in mixtures. This is attributed to good emergence and fast growth of red clover and orchardgrass seedlings as compared to alfalfa. On the other hand with August sowing, alfalfa seedlings were always aggressive toward red clover and orchardgrass. This is attributed to the poor stands and slower growth of orchardgrass and red clover than for alfalfa with August sowing. These seedling responses are attributed to the temperature and moisture conditions. In spring, the normally cool soils with high moisture favor the germination and growth of red clover and orchardgrass more than alfalfa. With summer seedings, the soil temperatures are warm and the moisture is not as favorable as in spring; this favors the development of alfalfa seedlings over other plants in the mixture. Orchardgrass should be limited to three pounds per acre in a mixture with alfalfa for spring sowing; because of its aggressiveness, red clover should not be used with alfalfa in spring sowing. We found that alfalfa yields and stands in hay crops were severely reduced by red clover when sown in spring.

Seedling aggressiveness applies to bringing new seedings into production sooner. For example, red clover seedlings are aggressive when compared with ladino clover. Thus, about three pounds of red clover with an orchardgrass-ladino clover mixture will increase the total yield and require less time for establishment. Adding one pound of ladino clover and three pounds of orchardgrass to a bluegrass-white clover mixture will shorten the establishing time and increase yields the first year or two. The seeding rate, species, time of the year when sown, and cutting or grazing management have profound effects on stands, yields, and plants in a sod.

Lime and Soil Fertility

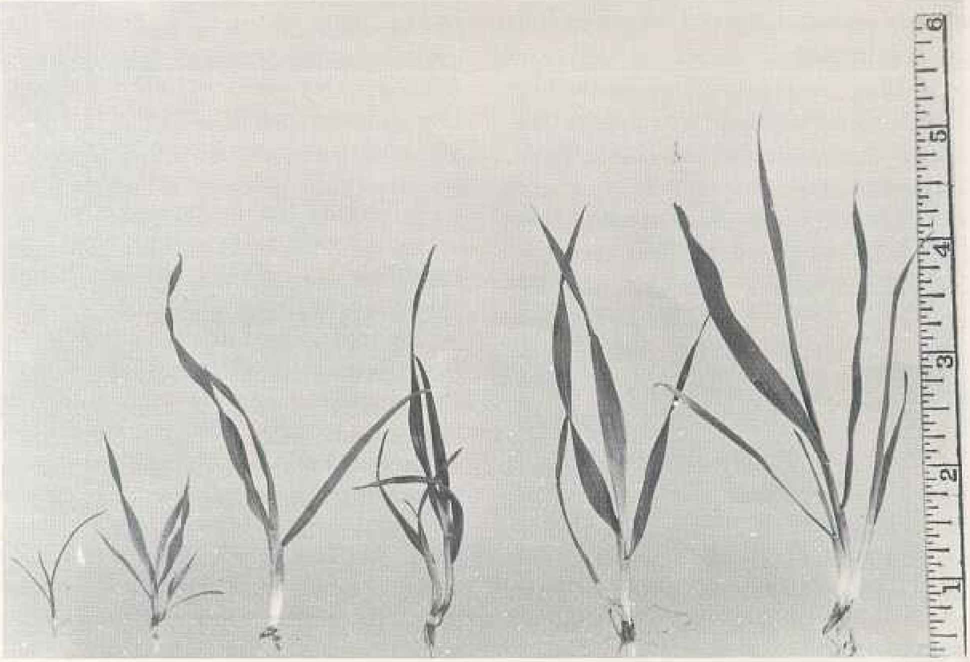
A grass-legume forage program really begins with adequate liming; the nitrogen fertility is low in almost all of the soils; hence, it is practical to grow legumes. Legumes, especially alfalfa, are very sensitive to low soil pH. Our experiments indicate that less phosphorus is required for maintaining stands of legumes where soils have been liberally limed. Although red and white clovers grow under acid soil conditions, a pH of six or higher should be maintained.

The applications of the various fertilizer nutrients and lime to soils have a profound influence on relative growth and competition among grasses and legumes. When lime, phosphorus, and potassium are supplied, grass-legume mixtures usually become legume dominant because of the nitrogen fertility. As the legumes improve soil nitrogen, the grasses begin to grow more rapidly causing light competition usual-



SEEDLING GROWTH AND COMPETITION: The different rates of seedling growth of grasses and legumes cause severe competition for light, weak seedlings are crowded out. The grasses and legumes were all seeded at the same time. Above photo left to right are alfalfa, red clover, alsike, ladino, white clover, and birdsfoot trefoil.

Below, grasses from left to right are bluegrass, timothy, orchard, Ky. 31 fescue, perennial ryegrass and Italian ryegrass.



ly reducing the clover component.

A lack of any fertilizer nutrient can cause decided shifts in the stand of grasses and legumes and total yield. For example, on soils that are very low in boron, alfalfa grows slowly as compared to grasses in a mixture; the mixture then becomes grassy and low in production.

Grasses are aggressive competitors for potassium. When soils are low in potassium, the legume stands are lost because the grasses absorb much more potassium than the legumes. Nitrogen fertilization on such low potassium soils causes even faster growth of the grass and more robbing of the available soil potash causing the legume stands to soon disappear. Grasses require less potassium for growth than legumes yet we find that the grasses are higher in this element. When soils are high in available potassium, the grasses are only a little higher in potassium content than the legumes. However, with low potassium, the legumes show severe deficiency symptoms and are much lower in potassium content than the leguminous associate. Because of the aggressive competition of grasses, grass-legume mixtures require more potassium than legumes grown alone.

When phosphorus is applied to low phosphate soils, grass and legume seedlings grow faster to give better stands and fewer weeds. Phorphorus is very necessary for high yields and stand maintenance of desirable grasses and legumes. The average hay yield of an alfalfa-orchardgrass mixture over a four-year period was 5300 pounds per acre without phosphorus and 7700 pounds when 50 pounds per acre was applied at establishment and yearly for maintenance. The hay yield was increased to 8,600 pounds when 100 pounds of phorphorus was applied for establishment and maintenance, as compared with 9,900 pounds of hay for 200 pounds of phorphorus at establishment and for maintenance.

Although almost all of the soils are low in nitrogen fertility, it is not usually practical to use nitrogen fertilizers on cool season grasses such as Kentucky 31 fescue and orchardgrass because the yields are not high enough. In a limited number of experiments with alfalfa-ordchardgrass mixtures, nitrogen gave very little or no response with good legume stands. When there was less than a 50 percent legume stand a nitrogen fertilizer increased the yields but it would probably have been more practical to reseed the legume.

Nitrogen at light applications may stimulate the total yields and seasonal distribution of growth on grass-clover mixtures. However, the little research on this phase at Middleburg shows rather poor responses from nitrogen on a bluegrass-white clover mixture (Table 42). Nitrogen at 40 pounds per acre depressed clover in the sod a little, four such applications of nitrogen reduced the clover from 39 percent to one percent of the sod. With liberal nitrogen fertilization, grazed or cut grasses recover very rapidly; the severe light competition causes the legumes to grow slowly and the sod becomes grass dominant. For nitrogen fertilized grass, ladino or white clover mixtures, it is necessary to graze early and closely during the spring to reduce the competition from the fast growing grass.

Forage Plants

The more important perennial grasses and legumes that may be grown in Virginia are discussed in this section. Often more important than the species is an especially adapted variety. For example, orchardgrass that has been produced in northern Virginia for many years is about as productive as any variety that has been bred by plant breeders. The best varieties of plants are those types that give the best yields under localized soil, temperature, moisture, and day lengths.

Alfalfa: Alfalfa is more productive and lives longer than any other legume when planted on adapted soils with good cutting management and alfalfa weevil control. It is used for silage,

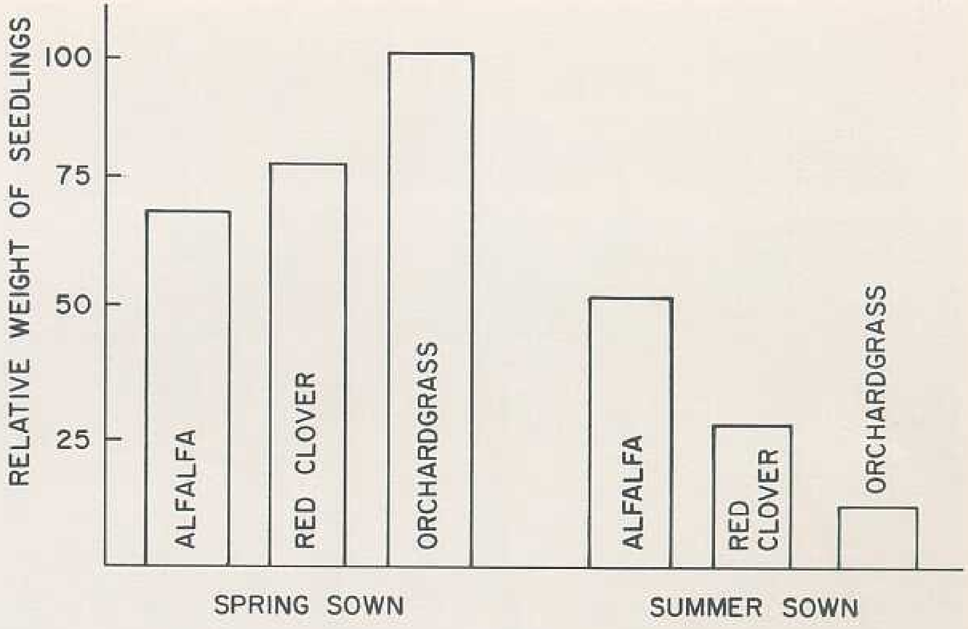


FIGURE 22. An alfalfa-orchardgrass-red clover mixture was sown in spring (March) and summer (August). Red clover and orchardgrass seedlings were aggressive toward alfalfa in spring but not in summer seedings.

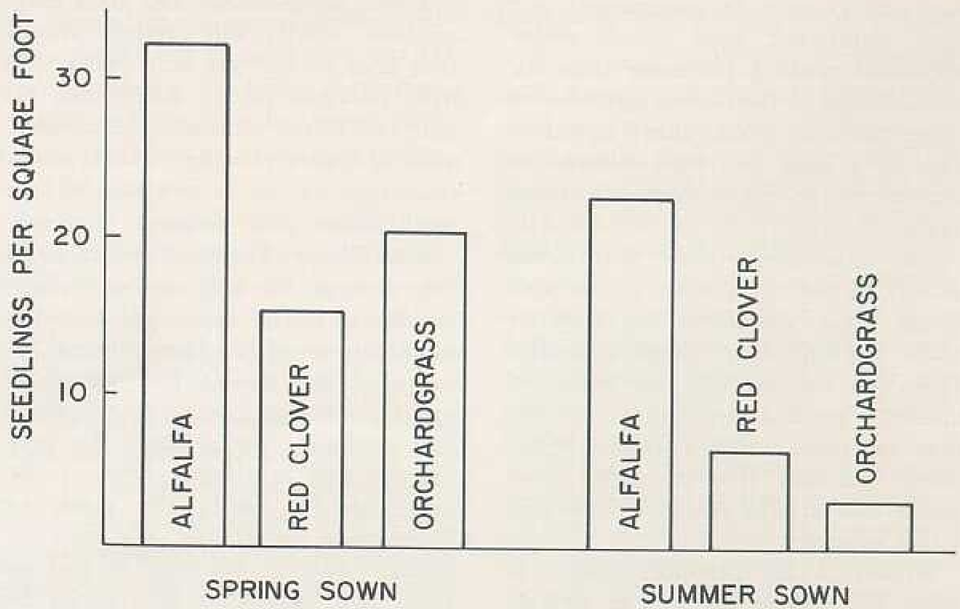
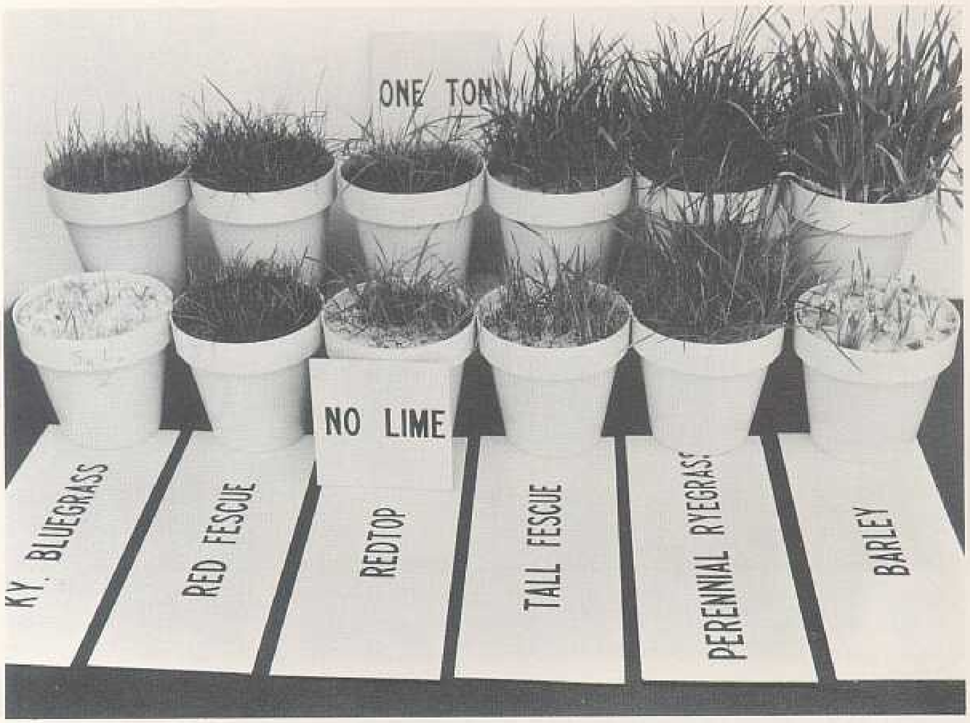


FIGURE 23. A mixture of alfalfa 10, red clover 7.5, and orchardgrass 3.5 pounds per acre was soded in March and August. The good stands and fast growth of red clover and orchardgrass seedlings in spring made them aggressive toward alfalfa.



COMPARING AGGRESSIVENESS: All grasses were seeded at the same date with one ton of lime per acre and no lime. Except for redtop, and red fescue, lime stimulated seedlings. The agressiveness of seedlings—rate of germination and growth—differed.

hay, and grazing. In experiments, we have maintained good stands under rotational grazing for more than six years. Stands in the bud to early flower stage should be grazed down in a few days to a week and then allowed to recover to an early flowering stage again.

Our experiments show that yields of alfalfa cut three times at the full bloom stage are about the same as when cutting four times annually. However, the protein and digestible nutrients per acre are higher for four than for three annual cuttings. When stands are cut five or more times yearly, the alfalfa stands deteriorated rather quickly.

Alfalfa alone produces about as much dry matter per acre as alfalfa-orchardgrass mixtures. Mixtures make alfalfa especially suitable for silage, hay, and grazing. Grass-alfalfa hay dries out quicker than alfalfa alone and the grass reduces encroachment of weedy plants.

Under suitable soils and good management, alfalfa will produce around four tons of hay per acre yearly. We have obtained six to seven tons per year but this is unusual. The development of higher yielding varieties would encourage its use in serving the livestock industry in Virginia.

Red Clover: During 1950 to 1960, the acreage of red clover declined rapidly as alfalfa increased; in recent years this trend has been reversed because of the alfalfa leaf weevil. If moisture is very favorable, red clover will produce about as much dry matter per acre as alfalfa; however, because of dry spells, the yields are lower than for alfalfa. We have obtained yields of six tons of hay per acre. This legume is best suited for short rotations where it is used alone or with a grass mixture for one to two productive years. All varieties of red clover regardless of management are short lived because of serious root diseases and insect damage.

Red clover with timothy makes an excellent horse hay but it is difficult to maintain good stands of timothy in competition with red clover. By using orchardgrass with red clover the yields may be increased by about ½ ton per acre; red clover should be grown with orchardgrass if harvested for more than two harvest years. It may be used flexibly for silage, hay, and grazing.

Ladino and White Clover: Ladino clover is especially useful when seeded with the taller grasses such as Kentucky 31 fescue and/or orchardgrass and used for silage and rotational grazing. The stands of ladino clover have been more persistent under rotational than with continuous grazing. White clover, smaller than ladino clover, is ideal in a bluegrass mixture for grazing.

The yields and longevity of ladino and white clovers are closely associated with good rainfall. These legumes are shallow rooted and not drought tolerant. A rainy season is usually a good clover season, because the surface runners with shallow roots spread rapidly.

White clovers are not hardy perennials as the main tap root rarely lives more than one year. The plants with shallow roots developing from the stolons are injured readily by dry weather and often heaved out of the soil during cold weather, causing subsequent desiccation of plants. Alternating low to higher temperatures at the soil surface often injures the axillary root and shoot buds in the surface stolons. Clover diseases occurring at different temperatures and seasons often injure or kill plants.

Birdsfoot Trefoil: A legume like birdsfoot trefoil would be an excellent asset to Virginia; however, none of the many varieties that have been tried from the United States and abroad can be recommended. Birdsfoot trefoil is susceptible to a summer disease known as *Rhizotonia* that kills stands during warm humid summer weather.

Lespedeza: Korean type annual lespedezas make an excellent quality hay and furnish good summer grazing. Because it is an annual, it must be grazed lightly during late summer to allow reseeding. Lespedeza grows best when the soil fertility is low because there is less competition from clovers and other plants during early spring. The main disadvantage of lespedeza is the low yield.

Orchardgrass: Orchardgrass has been used in northern Virginia for decades for forage and seed production. It is a very palatable grass in a leafy stage of growth but gets very woody as it approaches full bloom, when it is not readily eaten by cattle. Orchardgrass is an excellent component in mixtures for early cut hay or silage and grazing. To obtain good quality the spring growth that runs to stem should be harvested right after seed heads begin to emerge. When grown alone and fertilized liberally with nitrogen, it will produce around four tons or more of dry matter per acre. In our experiments, orchardgrass has been an excellent component in mixtures with alfalfa, red clover, or ladino clover. We have also used it with bluegrass-white clover mixtures under continuous grazing because it produces a sod rapidly and adds to the yield during the first two years. Its use for horse pastures is discussed in the section for horses.

The Virginia and North American strains of orchardgrass are rather erect growing plants that do not persist under heavy continuous grazing. Heavy continuous grazing causes near complete leaf removal of orchardgrass; other species then regrow faster and dominate over it. Close grazing also reduces the soluble carbohydrates stored in tillers and the rate of regrowth. Even under good management, orchardgrass sods are relatively short lived as compared with bluegrass and tall fescue.

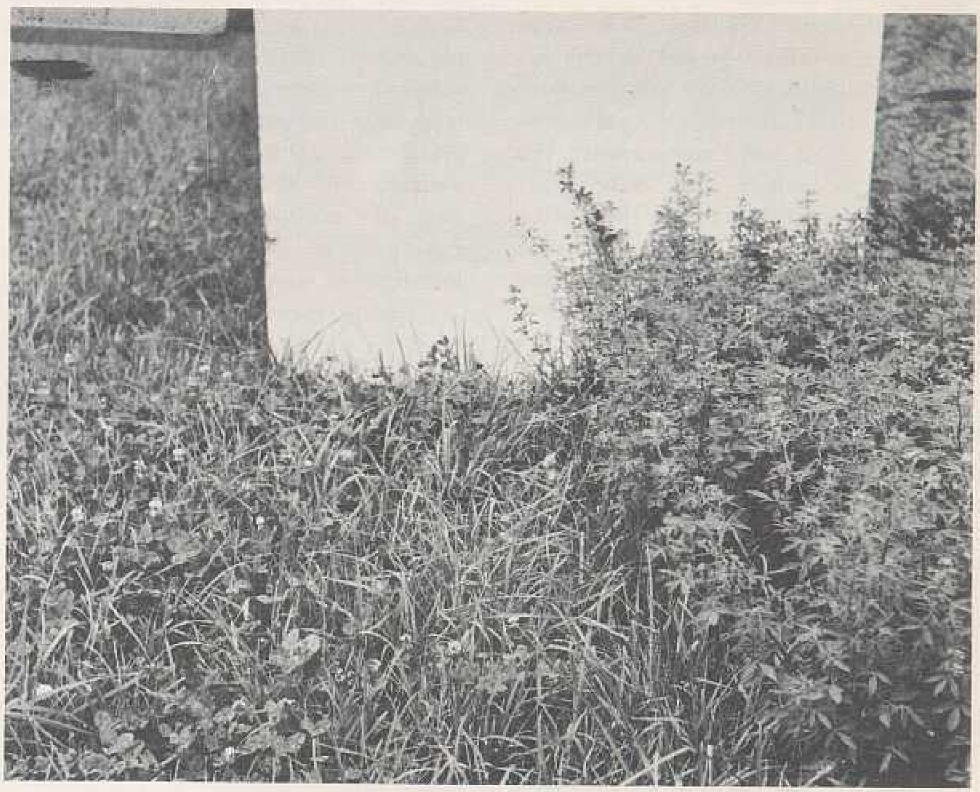
Kentucky Bluegrass: Kentucky bluegrass has been called a weed in some states; but in Virginia, pastures of it are about as productive as orchardgrass or Kentucky 31 fescue-clover mixtures. Bluegrass forms a persistent long-lived sod but some diseases lower its yield.

Kentucky bluegrass - white clover pastures are widely adapted to the cooler regions of Virginia. Bluegrass is one of the most persistent grasses and it is tolerant of over and undergrazing. It persists under continuous grazing. Ideally, it should not grow much over six inches high to maintain a good clover content. The managements to alter the grass clover balance is discussed in section for horse pastures.

Kentucky 31 Fescue: This grass is more widely adapted than any other cultivated grass used in Virginia. It grows at higher and lower fertility, drier and wetter soil situations, and lower and higher temperatures than other grasses. With nitrogen fertilization during the late summer-fall season, pasturage may be accumulated for winter grazing. The leaves are rather rigid and erect and maintain reasonably good quality for winter grazing. The chief objection to Kentucky 31 fescue is its low palatability as compared with bluegrass and orchardgrass. To overcome this, it should be kept short and leafy. Under continuous grazing, there is often severe over and undergrazing because the short fescue is more palatable than the tall grass. It does well under continuous grazing but better utilization may be maintained under rotational grazing.

This species causes animals to become afflicted with fescuefoot but this has not been a serious problem in Virginia. However, grazing Kenwell tall fescue has caused severe fescuefoot during two successive seasons with milk cows.

Although Kentucky 31 fescue may be used for silage, hay, and grazing,



MIXTURES VARY IN SUMMER PRODUCTION: Alfalfa, right, made vigorous growth during the summer because of deep roots, orchardgrass and ladino clover, left, are both shallow rooted and made slow summer growth.

it is most valuable for grazing because it is more palatable in a young leafy stage than when allowed to grow tall. Legumes such as red and white clover improve the quality of pastures as shown by better liveweight gains of cattle. It is more difficult to grow ladino clover with fescue than with orchardgrass because the wide adaptation of fescue mentioned above makes it very aggressive; in addition, cattle do not graze fescue closely and they tend to overgraze the areas high in ladino clover because of the higher palatability.

Timothy: Timothy grows better in pure stands with nitrogen fertilization than with legume mixtures. In red clover, it is an excellent mixture for horses. Timothy seems to be best adapted to the poorly drained soils that have a high water table during certain seasons of the year. Timothy is the most palatable grass tested at the research station.

Miscellaneous Grasses: We have tested many other grasses at the research station but they are not sufficiently well adapted. Coastal bermudagrass does not compete with the cool season grasses and stands die. Midland bermudagrass can be maintained if the early spring cool season grasses are killed with chemicals before bermudagrasses start to grow in late May when temperatures are high enough. The stands and quality are inferior. Reed canarygrass has desirable characteristics but it has been difficult to obtain and maintain productive stands. We have obtained rather good production of bromegrass when grown in pure stands and fertilized with nitrogen but none of the bromegrasses were persistent when grown with alfalfa and ladino clovers. The annual and perennial strains of ryegrasses tested more than a decade ago were not persistent. The summer temperatures were apparently too high.

Winter Annuals: Experiments are underway to evaluate rye, barley, and wheat for dry matter yields, protein content, and digestibility when harvested at various stages of growth. Early harvesting for silage may make it possible to obtain near normal yields of corn after small grains. Double cropping possibilities with summer annuals are being studied.

Summer Annuals: Sudangrasses, sorghum-sudan grass hybrids, pearl millets, and corn have been studied for dry matter production when cut at different stages of growth. It is not practical to substitute sorghum or any annual crop for a well managed corn crop that is planted early in the season.

With late season plantings, we have observed that summer annual grasses such as sudan-sorghum hybrids usually give better stands and produce more than corn hybrids. Although the summer annuals including corn grow during a much shorter season than the cool season grasses and legumes, they are remarkably productive as compared with the cool season grasses. In addition, the warm season annuals are not retarded during periods of higher summer temperatures when moisture is adequate. They are drought tolerant which is partially associated with depth of rooting. High potential production of summer annuals is associated with remarkably high capacities of accumulating dry matter during short periods of time when moisture is very favorable.

Cutting management has large effects on yields of dry matter and its quality. Corn maintains excellent quality for silage as cutting is delayed until the grain is almost mature. On the other hand, with all of the forage sorghums, sudangrasses, and pearl millet, the quality declines sharply as cutting is delayed. The highest yields are produced with infrequent or late cutting. For example, the sorghum-sudangrass hybrids produced less dry matter as cutting frequency increased. The dry matter yield was 29 percent less when cut frequently at a 20-inch height than less frequently at a height of 48 inches. However, the quality of the younger growth is much better than the taller growth cut less frequently.

RESEARCH AIMS IN THE NEXT DECADE

The net profits from livestock production enterprises are generally too low. The production costs of products from ruminants are high because of the price structure, the low efficiency of ruminants in converting foodstuffs into animal products, and the high costs of producing feed. For example, steers gaining more than 2 pounds of liveweight daily require 8 to 10 pounds of forage dry matter per pound of gain. This is an efficiency of 10 to 12 percent in terms of converting dry matter to liveweight gain. However, 14 to 18 pounds of dry matter are needed per pound of carcass weight, an efficiency of only six to seven percent. When the liveweight gains are around one pound daily, the conversion of feed to carcass weight drops sharply because proportionately more of the foodstuffs are used for maintenance.

Research is needed to reduce the costs of feed nutrients. Because of no harvesting costs, the costs of feed nutrients from pastures are comparatively low; however, the returns per acre are low because of low dry matter yields. Hay and silage costs per unit nutrient for perennial grasses and legumes are much higher than for corn because of lower yields and higher harvesting costs. In addition, corn silage is converted more efficiently to animal products than hay or silage from perennials because of better liveweight gains or higher milk production per animal which means less feed for maintenance. Thus, a primary research need is to reduce the costs of producing foodstuffs from perennial grasses and legumes.

There has been a strong emphasis on yield per animal but too little attention on the production of animal products per acre. Acre yields of animal products are often very low because of understocking and not using intensive managements. The successful farmer or research program for a livestock business must wisely manipulate the soil-plant-animal relationships to obtain optimum yields per animal and high yields per acre. The livestock program starts with a soil-plant system where as much of the radiant energy as possible is fixed in food-stuffs for ruminants in high yielding plants. The highest economic production of dry matter must be planned for the different soils through using the most productive plant and management system. The soil-plant program must be suitable for given animal raising programs. Thus, in future research programs, animal products must be produced more efficiently per animal and land area and this can be done by teamwork of scientists and an economist must be associated with this team to project profitability.

Pasture Problems

Research is needed to investigate the following: (1) Developing persistent long lived legumes so that productive grass-legume mixtures may be maintained. This is justified on the basis that higher gains and milk production per animal are obtained from grass-legume mixtures than for nitrogen fertilized grasses. (2) Improve pasture yields and obtain more even seasonal herbage production. Pastures produce about 60 percent of the growth during the first third of the grazing season which causes wasted pasturage during the spring. (3) To develop simple systems of pasture utilization for different mixtures and cattle enterprises. It may be more practical to graze continuously during the spring months when growth is rapid followed by intermittent or rotational grazing later in the spring season. (4) To investigate higher stocking rates with steers and cow-calf herds to improve production per acre. Grain supplements should be tried with high stocking. (5) To study nitrogen fertilization on grass-legume mixtures for dry matter and animal production efficiency. (6) To find inexpensive methods of renovating rundown pastures, especially those low in legumes. (7) To study fescue and bluegrass pastures under continuous grazing with stocking rates. (8) To find grasses that are more efficient in using nitrogen fertilizers.

Perennial Hay Crops

The yields of perennial grasses, legumes, or mixtures used for silage, hay, and supplementary grazing are too low. Because higher yields can reduce production costs, adaptative research should investigate all growth factors to obtain more dry matter per input unit. It is also necessary to find plants and management schemes to lengthen the season of production and develop more uniform seasonal yields. The leguminous plants should be long lived; hence, they must be tolerant or resistant to weed invasion, insects, and diseases. All of these factors that improve yield and persistence reduce production costs. The scientist has made only minor improvements in yield and quality over that in natural selections of temperate grasses and legumes. For example, natural selections of orchardgrass, bluegrass, tall fescue, and red clover produce yields similar to varieties developed by plant improvement programs. Perhaps, the research pursuits have been too weak as compared with the strong programs with corn.

If yields of perennial grasses and legumes cannot be sharply increased through plant breeding, fertilization, and utilization methods, then special plant explorations should be tried. Tropical and semi-tropical plants with morphology and germplasm similar to corn and sudangrass utilize the radiant energy more efficiently than perennial grasses and legumes. It may be possible to find semi-tropical plants that grow as perennials in mild temperate climates as in Virginia. At present, perennial grasses and legumes, because of low yields, cannot compete with the higher producing crops such as corn for the land.

Adaptative research must serve to increase yields, obtain longer seasons of growth, more even distribution during the year, and longer stands of perennial grasses and legumes that resist weed invasion. A perennial plant should be resistant to diseases and insects. High yields usually cause sharp reductions in production costs. For example, if alfalfa varieties with six tons yield per acre would have been available, it would have been more practical to spray for alfalfa leaf weevil control.

There should be an effort to develop high yielding grasses that use nitrogen fertilizer efficiently. Tall fescue grows earlier, over a longer season, and under drier soil environments than other perennial grasses. The developing of high yielding tall fescue varieties that are also highly palatable should have a high priority.

Developing perennial grasses and legumes that are high in utilizable energy to improve animal output is important, but increasing yields should have first priority. It will be more difficult to improve quality than yield.

Annual Plants

Double cropping the land each year should be investigated in view of obtaining maximum production per acre. Combinations of winter annual small grains followed by summer annuals such as corn, sudangrass, and sorghum hybrids should be studied. Small grains should be evaluated for silage, hay, and grazing. The annual crops should be harvested at several stages of growth to wisely compromise between the quality of dry matter production and yield per acre of dry matter.

Beef and Dairy Cattle

(1) The production of higher yielding better quality crops previously mentioned is all related to more efficient meat and milk production.

(2) Different spring and summer calving schemes should be investigated for economic efficiency of raising calves.

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(3) Intensive schemes of calf production through herd management and feeding practices that permit the smallest amount of feed and land area per raised calf should be the goal.

(4) The kind of silages and hay that are best for different classes of beef cattle should be further studied.

(5) Animal management schemes, where more animals are used for grazing during the spring than the summer and fall seasons should be developed.

(6) Combinations of forages from perennials with corn silage that reduce the costs of raising dairy and beef calves are needed.

(7) It would be desirable to develop complete rations through the self-feeding of silages.

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