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of the
36th Southern Pasture and Forage Crop
Improvement Conference

May 1-3, 1979
Beltsville, Maryland

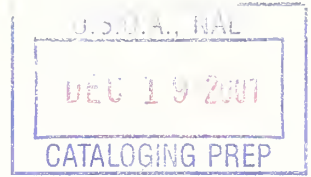
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PROCEEDINGS
OF THE
36TH SOUTHERN PASTURE AND FORAGE CROP
IMPROVEMENT CONFERENCE

May 1-3, 1979
Beltsville, Maryland

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SUMMER SYNDROME OF CATTLE GRAZING EXPERIMENTAL STRAINS OF TALL FESCUE

By J. B. Powell and J. Bond

For the past three years, we have conducted here at Beltsville a grazing experiment using four lines of tall fescue. These lines were made available to us by R. C. Buckner, USDA, University of Kentucky, Lexington. D. J. Undersander of the University of Maryland was involved early in the study. We set up 24, 0.5-hectare paddocks of four lines of tall fescue. The lines included 'Ky-31', 'Kenhy', a low perloline experimental line designated K-307, and a high perloline line, K-306. By measuring animal performance and observing animal behavior, it became apparent that the low perloline line gave a very different animal response than the other lines. The animals gained less, they stood in the shade approximately 40% more, laid in water 35% more, stood in the field 12% less, and grazed 36% less. In addition, they showed signs of emaciation, rough hair coat, elevated respiration, and excessive salivation. We obviously did not have to collect all these data to know that the animals were under stress. For three years we have watched this problem develop on these test plots. This is the summer syndrome problem, or sometimes called tall fescue toxicosis affecting animals grazing tall fescue. The malady is expressed in a much more severe form in this experimental line than in tall fescue varieties. Similar observations were made on this same line at the University of Kentucky. We involved many scientists in this problem here at Beltsville and elsewhere in an attempt to discover the causal factors which can explain this animal response.

To show you the problem, we have taken a short 16mm movie of these cattle grazing tall fescue last summer and the differential effects on one of these lines. The movie was made during one of the very warm days.

The first overall panoramic view shows eight of a total of 24 paddocks and shades for the animals which were placed in each of the paddocks. The movie was taken around noon in July 1978. Some of the cattle are grazing while some are under shades. Line K-307, the first pasture that is shown, is the low perloline line in which the animals exhibit symptoms of summer syndrome. You will notice that the cattle are under the shade and even though this was taken at close range, they are not moving away. We actually had to walk up and move them out of the shade. You can see that the animals are very dirty from lying in water and rather emaciated. They are not wild but rather docile.

An adjacent group of cattle in another pasture of Ky-31 showed none of the signs of those grazing the K-307. You will note that as we withdrew from the cattle, they returned to the shade. Again, they were moved away from the shade. This will show you more of the appearance of the cattle: Rough hair coat, dirty from lying in water (this is described by some as having an "alligator" characteristic, i.e., wallowing in water.) The film shows other

cattle in the paddocks which were much cleaner. K-306 is adjacent to Kenhy in this view. These cattle did not exhibit the same level of heat stress as those grazing K-307. Although all animals were subjected to high environmental temperatures, only the steers grazing K-307 showed the symptoms of summer syndrome.

The next replicate is very similar to the first. Cattle are out grazing Ky-31 even though the shade was provided at the time we took these pictures. The cattle appear normal and move rather vigorously.

The adjacent variety in this replicate is Kenhy. Again, the cattle have good appearance and are not unusually stressed for this warm, summer day.

In the K-306 pasture, the cattle are grazing; they are in very good shape and some were even running when we took these pictures.

The paddocks were clipped at approximately 13-15 cm level to keep the physiological stage of the grass the same. The grasses were not allowed to head. Excess clippings were removed.

The final paddock is the second replicate of K-307, the low perloline line that has the problem expressed. The first steer, as you view it, is standing at the edge of the shade. All the other cattle are in the shade. There is an obvious difference in the amount of forage being grazed. The K-307 is not being grazed as intensely as the adjacent K-306. As we walked closer to the cattle to get a better look one steer was lying in the mud in the shade and did not want to move. He finally did get up, but moved rather slowly in getting around, rather weakly. The cattle in this paddock are very rough, very muddy, lying in any kind of water they can find. They were moved out from the shade but they would not stay away from the shade very long. Note their return at the first opportunity. One steer we saw out grazing is next to its watering trough. We were not sure as we watched this animal whether it was going to remain standing or not. It seemed to teeter back and forth a little, but managed to keep standing.

We wish that we could say that we know the chemical constituents in K-307 that interact with the animal to give their heat sensitivity response. We do believe that the thousands of samples that have been collected from the grass as well as the animals, and the interdiscipline cooperative approach to problem solving will permit this problem to be examined in a way that previously has not been possible. An assessment of the chemical constituents of the tall fescues involved in this study are continuing. Solving this problem with constantly varying forage chemical constituents, constantly varying animals, constantly varying environments, and their interaction is a major challenge. Leads to the solution of this problem have been investigated for three years without designing experiments to clearly define the problem. One real attribute of this research is the national approach and interdiscipline effort that it has generated. We believe tall fescue is much too valuable a plant species to allow this problem to limit its true potential in American agriculture. Thus, we will continue to research the problem.

UTILIZATION OF MUNICIPAL SLUDGE MATERIALS IN FORAGE-LIVESTOCK SYSTEMS

By A. M. Decker, R. L. Chaney, J. R. Davidson, R. C. Hammond, S. B. Mohanty,
and T. S. Rumsey

A pasture which had been ungrazed for about two years was clipped several times in 1975 so that by the spring of 1976 the sward was essentially weed-free tall fescue with some Kentucky bluegrass throughout and scattered patches of bermudagrass.

Early in 1976, 2242 kg of high Ca lime and 500 kg/ha of an 0-15-30 fertilizer were uniformly applied to the area. The area was divided into 0.3 hectare paddocks which were grouped into four "uniform" 3-paddock units. The following pasture treatments were assigned at random to each of the 3-paddock units:

1. Ammonium nitrate (50 kg N/ha) applied 21 days before grazing.
2. Liquid sewage sludge (51 M³/ha) applied 21 days before grazing.
3. Liquid sewage sludge (51 M³/ha) applied one day before grazing.
(This treatment was replaced after the first year with a sludge compost treatment - a total of 134 dry MT/ha applied in split applications in the spring and twice during the grazing season. Compost was applied only twice in 1978).

Liquid sludge and compost rates were chosen to approximate available N applied as NH₄NO₃.

Angus cows with nursing calves, approximately 2 months old, and Angus steers were used as tester animals. For 30 days prior to going on test, animals were held in quarantine and monitored for base levels of virus and parasitic infections. Put-and-take grazers were used in an attempt to maintain uniform grazing pressures. Water, salt, and bonemeal were available free-choice in each paddock. A 4-paddock rotational grazing system was used. Animals grazed each paddock for 7 days leaving a 21-day rest period between each grazing. Pastures were clipped after each grazing. Three 9.1-meter yield strips were obtained in each paddock before and after grazing. Forage samples were obtained for protein, IVDMD, and mineral analyses. Soil samples were taken prior to and periodically throughout the study. Live weights were determined and milk and feces samples were collected each week. Blood samples, nasal swabs, and rectal swabs were taken once a month. Pastures were grazed for three seasons.

At the end of each season, a complete postmortem examination was performed. Both gross and microscopic evaluations were made of organs, bones,

and tissue. The liver, kidney, spleen, duodenum, bone, and muscles were analyzed for heavy metals.

After the 1976 grazing season, grazers, which had been on day-1 and day-21 sludge treatments during the entire season, were grazed on untreated tall fescue pastures for approximately 60 days and then subjected to a complete postmortem examination.

Two WSSC liquid sludges were used in the study. Although both were low in heavy metals of concern (i.e. "Domestic Sludges"), one was high in Fe (11%) as a result of ferric chloride additions to the wastewater to improve sewage treatment.

Excellent forage growth resulted on both liquid sludge- and sludge compost-treated pastures. Yields were comparable to pastures receiving 252 to 303 kg N/ha. Percent crude protein and IVDMD were similar on forages from each of the three pasture treatments.

Forage consumption was markedly reduced when animals had access to pastures freshly sprayed with liquid sludge; consumption was similar on pastures fertilized with compost, NH_4NO_3 , and "low-iron" liquid sludge applied 21 days before grazing.

Animal performance was very poor on pastures freshly sprayed with "high-iron" sludge. Performance was good to excellent on pastures sprayed with "low-iron" liquid sludge 21 days before grazing, treated with raw sludge compost, or fertilized with NH_4NO_3 . When weight losses occurred they were greatest on the cows followed by steers and then the calves. Cattle on all liquid sludge pastures retained their winter coats longer than those on compost or NH_4NO_3 pastures.

Enteroviruses isolated from cattle on the various pasture treatments were normal viral flora of the bovine intestinal tract rather than of sludge or compost origin. Viruses isolated during the study appeared to be associated with animal stress rather than pasture treatment per se.

Parasitic ova found in the feces of test cattle were within the normal range and not associated with pasture treatment.

Spray-applied sludge adhered to foliage, dried, and remained on forage even through extensive rainfall. Analyses of feces for metals showed that cattle consumed the contaminated forage. Although compost-fertilized forage was not contaminated by compost adhering to the foliage, cattle apparently consumed compost from the sward thatch and from the soil surface while grazing.

Arthritic erosion of articular cartilage noted in the tibial-tarsal joint which initially appeared to be sludge-related may in fact be more a function of stress and/or normal aging. Additional work is underway attempting to clarify these findings.

The most significant gross and microscopic lesions observed in the sludge exposed animals related primarily to iron accumulation within a variety of

tissues, most notably those related directly or indirectly to the digestive system. Iron uptake by these tissues was directly proportional to iron present in the sludge and/or the amount of sludge consumed, but inversely proportional to the length of time between the last exposure to the metal-containing sludge at the time of necropsy.

Ingestion of large amounts of iron and other heavy metals by grazing animals was more a matter of direct consumption of sludge or compost than it was consumption of forages that had taken up large amounts of heavy metals from the sludge- or compost-treated soil.

Different animal tissues were specifically analyzed to observe any accumulation of Cd, Pb, Zn, Fe, Cu, Ni, and Mn. Analyses of all tissues revealed no statistically significant sludge-related increases in heavy metals other than Fe. There was, however, a small but consistent increase (not statistically significant) in kidney Cd which seems to imply that aged cows from cow-calf farm operations will have somewhat increased kidney Cd at slaughter compared to animals not exposed to sludge- or compost-treated pastures; results from the present studies can not answer whether kidneys of these aged cows will require disposal rather than sale. Iron content of liver, spleen, and intestine indicated Fe toxicity may have caused the poor animal performance observed. The surface application of sludges, especially "high-iron" sludges, on pastures is clearly contraindicated.

A controlled feed lot study is presently underway attempting to find answers to some of the questions raised by the grazing experiment; it is a six-month feeding experiment scheduled to terminate about June 1, 1979. Diets being fed are as follows:

1. Pelleted pearl millet forage grown on land fertilized with NH_4NO_3 .
2. Pelleted pearl millet forage grown on land fertilized with 22 $\frac{1}{4}$ dry metric tons/hectare of composted limed raw sludge worked into the soil prior to seeding.
3. Pelleted pearl millet forage grown on land fertilized with NH_4NO_3 with 3.3% of the final diet being sludge compost (dry basis).
4. Same forage as treatment 1 and 3 with 10% of the final diet being sludge compost (dry basis).

Types of animal used, animal measurements, feed analyses, and animal tissue analyses are similar to those used on the grazing experiment. In addition blood samples are collected every two weeks to determine serum levels of 23 different analytes in an attempt to identify biochemical alterations during the feeding trial. Complete blood counts are also being made.

One-half of the animals are being necropsied at three months and the other half at the end of the six-month trial. The same type of data are being collected as in the grazing study.

Rumen contents are being sampled, via the fistula, at 28-day intervals to observe any changes in the physiological state of that organ. Attempts will be made to correlate alterations noted in the rumen with other physiological changes observed. As background for the feeding study, rumen samples were also collected during the last year of the grazing study.

RESEARCH ON THE CONTROL OF FACE FLIES ON PASTURED CATTLE

By R. W. Miller, L. G. Pickens, and D. M. Nafus

The two main fly pests of pastured cattle are the horn fly, Haematobia irritans (L.), and the face fly, Musca autumnalis De Geer. The horn fly spends most of its life directly on animals where it obtains blood meals, primarily from around the withers and back area. It is therefore relatively easy to control by either hand dusting with any of several insecticides or by applying the same insecticides with self-applicatory devices such as dust bags or back rubbers.

The face fly, like the horn fly, is a pest of pastured cattle; however, its habits differ considerably from those of the horn fly. The face fly, as the name implies, is found primarily on the faces of cattle (and horses) where it feeds on secretions of the eyes and nostrils. The face fly is a relatively recent pest in the United States, having been introduced into North America through Nova Scotia in 1952. Since that time it has spread southward and westward and is now present in every state within the continental United States with the exception of Florida, Louisiana, Texas, Arizona, and New Mexico.

Besides annoying cattle, thereby interfering with normal grazing activities, the face fly is a mechanical vector of Moraxella bovis, the organism responsible for bovine pinkeye and a true vector for several species of eye worms (Thelizia spp.).

Unlike the horn fly, the face fly is very difficult to control. Although face flies are quite susceptible to many approved insecticides, adequate control of this pest is difficult to achieve. There are several reasons for this:

1. The face fly is only a pest of pastured animals and does not enter buildings or barns except to overwinter.
2. It is difficult to obtain adequate coverage of insecticides on the faces of animals whether they are applied by hand or with self-applicatory devices, and the insecticides do not remain on the faces for an extended period.
3. Only a small percentage (ca. 5%) of the face flies in a pasture are on the cattle at any one time and these leave the animals each evening.
4. Face flies commonly migrate for up to 2 miles or more, which makes control on individual farms nearly impossible.

Because of the problems associated with the face fly and the difficulty in controlling it, the face fly is considered the most important cattle pest in many areas of the United States.

Two habits of the face fly, however, offer control possibilities.

(1) Face flies lay their eggs (oviposit) in fresh cattle manure, where they hatch and develop as larvae, and (2) adult face flies are attracted to white painted plywood panels.

In the Livestock Insects Laboratory here at Beltsville, we have been conducting research on techniques to control face flies both in the larval stage and as adults. Research on the control of face flies in the larval stage has involved the use of feed additives, or feed-through compounds, as they have come to be called. These are compounds which are administered to cattle either in the ration or in a mineral supplement, pass through the digestive tract, and kill the face fly larvae developing in the manure. We have tested a number of insecticides and compounds known as insect growth regulators for this usage in the past years, and one of them, an organophosphorus insecticide, stirofos (sold under the trade name of Rabon) is now registered for use with both non-lactating and lactating cows. It is the only compound presently registered as a feed additive for face fly control with lactating dairy cattle.

Our laboratory has also done extensive research on attracting adult face flies to white plywood panels or pyramids. We tested various shapes and configurations and concluded that a three or four sided pyramid placed ca. one meter above the ground was the most efficient trap for face flies. A somewhat less efficient trap, but one which is easier to construct and maintain, consists of a 60 cm square white painted plywood panel. Both the pyramids and the flat panels are covered with a sheet of clear plastic and painted with an adhesive such as Tack-Trap.

After considerable development on both the feed-through approach and the attractant traps at Beltsville, we began a 3 year pilot test to evaluate these control strategies in the field. For this test we selected four areas in Howard county, Maryland. Last summer we monitored face fly populations on all farms within the areas by means of pyramid traps and face counts. During the next two summers we will attempt to control face flies in three of the four areas. In one area all of the cattle will be fed Rabon either in their concentrate ration or as a self-fed mineral supplement. In a second area white plywood panels will be placed in all pastures containing cattle; the sticky plastic holding the trapped flies will be changed on a regular basis. In a third area the cattle will be fed Rabon and the pastures will also have the panels. This latter treatment is an example of integrated pest management. The fourth area will be used as a check and no treatment for control of face flies will be used except what the farmers may use on their own.

We would hope that by the end of next summer we can come up with recommendations for control of this important fly pest of pastured cattle that will be more effective than those presently in use.

USE OF TISSUE CULTURE AND GENETIC ENGINEERING TECHNOLOGY FOR DEVELOPMENT
OF MICROBIAL INSECT CONTROL AGENTS

By Robert M. Faust and James L. Vaughn

INTRODUCTION

Although precise figures on total crop losses caused by insect pests are somewhat difficult to obtain, it has been estimated that these losses to world agricultural production are in excess of \$4 billion per year. In any event, there is no doubt that such insects affect plant vitality and productivity, and therefore, food production for humans and forage animals. Further, increasing problems with chemical insecticides, i.e., insect resistance, insecticide residues, toxicity to non-target organisms, and environmental and health hazards have increased the search for and use of safer but effective insect control agents. Unfortunately, few microbial agents have enjoyed success because of difficulties with efficacy and mass production comparable to chemical insecticides. Of those microbial control agents enjoying some success only Bacillus thuringiensis useful for control of lepidopterous pests on forage crops has been amenable to in vitro production on a relatively large scale. B. popilliae, a pathogen causing the milky spore disease of Japanese beetle larvae, and the few insect viruses approved by the Environmental Protection Agency (EPA) for use as biological insect control agents are limited in their use because of the lack of in vitro mass production methods for world-wide dissemination.

Alternative avenues of fundamental research, such as genetic engineering of entomopathogenic bacteria, and development of tissue culture technology for the mass in vitro production of viruses affecting forage crop insect pests could lead to resolution of efficacy, in vitro fermentation problems, and allow commercial production feasibility. Subsequent applied research on the pathogenicity, safety, and environmental stability may allow the mass industrial production of highly selective and virulent agents competitive with chemical insecticides. Ultimately, mass produced biological control agents should result in a decreased use of hard chemical insecticides.

PLASMID AND RECOMBINANT DNA TECHNOLOGY IN THE DEVELOPMENT
OF ENTOMOPATHOGENIC BACTERIA

Microbial Genetic Engineering

The deliberate modification of the gene structure of prokaryotic microorganisms so as to achieve a human benefit is not a new concept. For many years, microbiologists and fermentation engineers have been "engineering" microorganisms to produce strains that would permit increased production

rates and culture stabilities in industrial fermentations, enhance the yields of valuable microbial gene products (e.g., amino acids, alcohols and antibiotics), or improve the quality of foods or beverages conventionally prepared by fermentation. The technique used to create these conventional "genetically engineered" strains is to expose the microbes to mutagenic agents and then select mutants having the desired performance characteristics. This technique permits only limited, localized changes in the gene structure of the microbes used, typically, those affecting the expression of genes already present. Hence, it results in genetically engineered mutants with metabolic capabilities that differ quantitatively rather than qualitatively from those of their progenitors. Consequently, these conventional mutant strains cannot offer any human benefit that is not offered to at least some small degree by an existing wild microbe.

Since 1974, a powerful new technique for microbial genetic engineering, in vitro recombinant DNA formation, has permitted the development of a new type of mutant strain. These recombinant DNA strains must be regarded as mutants of the original parent, since their overall genetic composition is still more than 99% that of their progenitor. They differ from the earlier man-made mutants, however, in that the last 0.1 to 1.0% of the gene structure may contain additional types of genes, including some that might never be introduced by natural gene transfer processes. As a result, they may (1) exhibit metabolic capabilities that are qualitatively different from those of the unmutated parent; (2) offer qualitatively new types of human benefits, such as the production of eukaryotic gene products by prokaryotic microbial fermentations or development of more efficient and effective insect biological control agents to protect the world's food crops in lieu of a number of non-selective and dangerous chemical insecticides.

In our research project at the Insect Pathology Laboratory we are investigating the multilateral relationships that govern the interactions in a system consisting of target host insect, bacterial pathogenicity, and DNA-mediated parameters for successful development of biological control agents. Our project is based on a set of working hypotheses, which if proven correct could account for many of the observations and data assembled on proliferation and pathogenicity to date: (1) Extrachromosomal DNA elements are responsible for production of B. thuringiensis parasporal crystals (δ -endotoxin) imparting toxicity to lepidopterous, dipterous, and coleopterous pest insects. (2) Failure of B. popilliae vegetative cells growing in artificial media to sporulate is the result of metabolic lesion(s) resulting from long association as a pathogen growing in Japanese beetle hemolymph. (3) Unadulterated and recombinant DNA plasmids can be expressed in transformed strains and may improve their spectrum of activity, pathogenicity, and in vitro fermentation ability.

Extrachromosomal DNA plasmids are circular DNA molecules in the molecular weight range from a few million to a few hundred million daltons. They replicate independently within bacterial cells and carry useful, but frequently dispensable, genetic information. Table 1 lists some properties coded by plasmids found in bacteria. Some of these plasmids are able to promote their own transfer from one cell to another, and some of these are not confined to bacteria of the same species. A few have a very broad host range, including many Gram-negative bacteria. Therefore, at least the genetic information encoded in the DNA of some plasmids is freely exchanged between very different bacteria. In fact, DNA plasmids are generally the

TABLE 1.--Some properties coded by plasmids

Fertility	Metabolism of camphor, octane
Bacteriocins production	Tumorigenicity in plants
Antibiotic production	Restriction/Modification
Heavy metal resistance	Virulence factors - Haemolysin K 88 antigen
UV resistance	Parasporal crystal production
Enterotoxin production	

vectors used in many recombinant DNA studies for inserting desirable genes into selected hosts. Once introduced by transformation procedures the genes are presumably expressed and give the modified strain the desirable attributes envisaged by the investigator.

Each of the aforementioned hypotheses are being tested experimentally and we believe that the research will delve into areas of investigation in insect pathology where in the past little progress has been made. Virtually nothing is known about the mechanism of specificity of different strains of *B. thuringiensis* for pest insects and the molecular events accompanying them. If some of our ideas are correct, this could be due to highly specific plasmid gene variations coding for the δ -endotoxin. A clearer insight into the expression of plasmids could make profound contributions to such basic questions as the origin of genetic information in construction of toxic parasporal crystals, the function of the numerous plasmids found in various strains of entomopathogenic bacteria, or the molecular mechanism of symptom expression. The abundance and variety of extrachromosomal elements in these organisms has allowed their isolation and purification in sufficient quantities for detailed study of the structure and biological properties of these molecules and for genetic manipulation by simple transformation or recombinant DNA techniques of promising plasmids to ultimately improve the efficiency, pathogenicity, and commercial production of entomopathogenic bacteria.

The objectives of our research with DNA manipulation of entomopathogenic bacteria are: (1) development of competency for uptake of foreign DNA, (2) isolation and characterization of indigenous extrachromosomal DNA's, (3) elucidation of the fundamental genetic factors responsible for pathogenicity and/or production of toxic entities, (4) development of DNA-mediated transformation systems in the bacillus group of insect pathogens, (5) genetic construction and selection of entomopathogens for specific biological control purposes by combining genetic information for pathogenicity into one entomopathogenic bacterium using plasmid/recombinant DNA technology, (6) selection of promising new strains for commercial development with particular emphasis on safety, activity spectrums, mode of action, genetic stability, and fermentation capabilities, (7) demonstration of usefulness of entomopathogenic bacteria as model/alternate host-vector systems for a variety of recombinant DNA studies in other fields of genetic endeavors, and (8) facilitation of in

in vitro commercial production of the more fastidious insect pathogens by expanding the range of in vitro substrates upon which they can grow. Table 2 lists the more important entomopathogenic bacteria having the greatest potential for wide-spread biological control and genetic manipulation or combining of genetic information for pathogenicity into one or more entomopathogenic bacteria, thus increasing its spectrum of activity.

The Nature of Entomopathogenic Bacteria

All entomopathogenic spore-forming bacteria produce endospores which allow them to persist in a dormant or quiescent state outside the intended host. Upon ingestion by a susceptible host the spores may germinate in the gut. In obligate pathogens in the genus Bacillus, the vegetative cells produced by the germinating spores enter the hemocoel where they multiply rapidly, destroy certain tissues, and soon fill much of the cavity. Prior to death of the host, thick-walled refractile spores are formed which appear white through the integument, thus the name "milky disease". The causative organisms of "milky disease" are B. popilliae, B. lentimorbus, B. fribourgensis, and B. euloomarahae, and affect primarily beetle larvae of the insect order Coleoptera (Dutky, 1940). Following death, the host disintegrates and the spores are released into the soil. The mode of action of obligate pathogens of the genus Clostridia differs in that these bacteria multiply only in the gut and do not invade the hemocoel. After death, the cadaver becomes shrunken, dry and mummified. As a group, the spore-forming obligate pathogens are highly virulent for specific insect hosts and kill apparently without producing highly poisonous toxins that aid in infection or cause death.

The crystalliferous sporeformers (varieties of B. thuringiensis), in addition to forming endospores, produce a proteinaceous parasporal crystal in the sporangium at the time of sporulation. The crystal contains the δ -endotoxin capable of paralyzing the gut of most pest lepidopterous larvae (Heimpel, 1967) and some pest mosquito larvae depending on the B. thuringiensis strain (de Barjac, 1978a,b).

Clostridial pathogens were originally isolated from Malacosoma californicum (pluviale) (Bucher, 1957). Other than experimental infections in other tent caterpillars and the possible presence of these bacteria in Thymelicus lineola (Heimpel and Angus, 1963) little is known about their host range. B. thuringiensis and its varieties have been tested successfully against more than 137 insect species from the orders Lepidoptera, Hymenoptera, Diptera, and Coleoptera (Heimpel, 1967). Most of these pathogenicity tests have been conducted in the laboratory. The most susceptible insects are those lepidopterous larvae having alkaline gut contents (pH 9.0-10.5) and enzymes which dissolve the crystals and release the toxin (Angus, 1956; Angus and Heimpel, 1959; Heimpel and Angus, 1959).

Unfortunately, as mentioned previously, there are several obstacles to the commercial production and wide-spread use of many biological control agents. For example, the wide-scale biological control of the Japanese beetle, Popillia japonica Newman, the European chafer, Amphimallon majalis Razoumowsky, and other susceptible scarabaeid grubs, major pests of lawns, pastures and other plant life in many parts of the world could be considerably facilitated by the development of an in vitro industrial method for spore production of B. popilliae. Spore preparations of B. popilliae are produced commercially by collecting living larvae from infested soil, injecting each grub with the disease organism, incubating the larvae until the blood becomes filled with

TABLE 2.--Important entomopathogenic bacteria having the greatest potential for wide-spread biological control

Bacterial species	Hosts	Mechanism of action
<u>Bacillus popilliae</u> , <u>lenti-morbus</u> , <u>fribougenensis</u> , <u>euloomarahae</u>	Coleopterus larvae, especially Japanese beetle and European chafer	Causes "milky spore disease", septicemia
<u>B. thuringiensis</u> varietal types such as <u>kurstaki</u> , <u>sotto</u> , <u>dendrolimus</u> , <u>alesti</u> , <u>entomocidus</u>	Numerous lepidopterous pest larvae	Parasporal crystal toxin, disruption of midgut wall, paralysis
<u>B. cereus</u> (<u>thuringiensis</u>) var. <u>juroi</u>	Mosquito larvae (<u>Culex</u> , <u>Aedes</u>), some Lepidoptera	Cuboidal crystal toxin, disruption of gut wall
<u>B. thuringiensis</u> BA 068	Mosquito larvae (<u>Aedes aegypti</u> , <u>Culex</u>), some Lepidoptera	Parasporal crystals (bicrystalliferous) and bacteremia
<u>B. t.</u> var. <u>israelensis</u>	Mosquito larvae (<u>Aedes aegypti</u> , <u>Anopheles</u> , <u>Culex</u>)	Parasporal crystal toxin, disruption of midgut wall
Special HD strains of <u>B. thuringiensis</u> (<u>kurstaki</u> , <u>thuringiensis</u> , <u>tolworthi</u> , <u>galleriae</u> , <u>morrisoni</u>)	Mosquito larvae (<u>Aedes</u> and <u>Culex</u>), some Lepidoptera	Parasporal crystal toxin, septicemia
<u>B. moritai</u>	Housefly, stable fly, seed-corn maggot	Toxic principle of <u>in vivo</u> growing bacteria, inhibits larval development
<u>B. sphaericus</u> (SSII-1)	Mosquito larvae (<u>Culex</u> , <u>Culiseta</u> , <u>Aedes</u>), Clear Lake gnat	Toxin-mediated, located in outermost cell wall layer, disrupts midgut wall
<u>B. alvei-circulans</u>	Mosquito larvae (<u>Culex</u>)	Heat labile soluble toxin, action unknown
<u>B. cereus</u>	Hymenoptera, Lepidoptera, Coleoptera	Septicemia
<u>C. malacosomae</u>	Tent caterpillar	"Brachyosis", bacteremia of gut, toxic paralysis
<u>C. brevifaciens</u>	Tent caterpillar	"Brachyosis", bacteremia of gut, toxic paralysis
<u>Clostridium</u> sp(?)	Essex skipper larvae	"Brachyosis", bacteremia of gut, toxic paralysis

spores and then grinding and mixing them with an extending material such as talc. This procedure results in an expensive low-yielding product incapable of meeting the requirements for adequate mass control of these serious insect pests throughout the world.

Despite approximately 35 years of research and voluminous data concerning the pathogenicity, physiology and biochemistry of B. popilliae, an extremely fastidious organism, the development of in vitro methods for large-scale production of infective spores, a form that is necessary for long-term survival and control of the insect, has not been realized. The low sporulation of selected strains, using developed media of previous investigations, require a 10 to 15 day incubation period with rare production of sporulating vegetative cells. Such spores are only minimally infective to Japanese beetle larvae per os. This negative feature is also extended to the clostridial entomopathogens.

Alternative avenues of fundamental research, such as transformation and/or recombinant DNA formed from fermentation or sporulation genes of B. thuringiensis, an inexpensively grown and readily sporulating insect pathogen, could lead to resolution of this problem. Another organism, Bacillus sphaericus, a potentially powerful biological control agent for mosquitoes, is not readily grown in cheap culture media, but requires rather expensive nutrient additives for optimum production. Under our present knowledge and technology, this organism would not be commercially feasible for industry to develop at this time and hence its widespread use is hindered in lieu of such organophosphate insecticides as malathion. The pathogenicity of this organism for mosquito larvae seems to reside in the capacity for the production of an endotoxin specific for its host midgut (Davidson et al., 1975). Recombinant DNA incorporation of the genes responsible for production of this toxin and transformation into B. thuringiensis, the biological lepidopteran insecticide being produced at a price competitive with chemical insecticides, could yield a broader-spectrum biological control agent affecting several orders of economically important insect pests and although broader based, this new strain would be selective, an attribute not contained in many chemical insecticides. Their development and use could result in a decreased use of hard chemical insecticides. In fact, a recently isolated strain of B. thuringiensis (var. israelensis) has demonstrated that the parasporal crystals (δ -endotoxin) are toxic for such pest mosquito larvae as Aedes aegypti and Anopheles stephensi, but is not toxic to larvae of Lepidoptera (de Barjac, 1978a). Combining of these pathogenic entities into one strain would give commercial industry a very valuable and fruitful product. B. moritai, pathogenic for houseflies, stable flies, and the seed-corn maggot (Fujiyoshi, 1973) produces a toxic principle that inhibits larval growth - similar research approaches as described above may also prove to be advantageous.

Present Status of Genetic Manipulation with Entomopathogenic Bacteria

We have now examined four entomopathogenic bacteria for indigenous plasmid DNA molecules in order to ascertain extrachromosomal DNA profiles prior to developing DNA transformation systems. The basic characteristics of the larger isolated elements, especially the giant DNA elements, are not unlike those of representative plasmids isolated from members of other genera of bacteria (Clowes, 1972,1973). Bacillus thuringiensis var. kurstaki contained twelve elements banding on agarose gels that ranged from 0.74 to $>50 \times 10^6$ daltons, 3 of which were giant extrachromosomal DNA elements. B. thuringien-

TABLE 3.--Number and size estimation^{a/} of extrachromosomal DNA elements of Bacillus thuringiensis var. kurstaki, var. sotto, var. finitimus, and Bacillus popilliae isolated by agarose gel electrophoresis

<u>B. t.</u> var <u>kurstaki</u>	<u>B. t.</u> var <u>sotto</u>	<u>B. t.</u> var <u>finitimus</u>	<u>B. popilliae</u>
>50 x 10 ⁶		>50 x 10 ⁶ (2)	
~45 x 10 ⁶			
~29.9 x 10 ⁶	~23.5 x 10 ⁶		
~17.1 x 10 ⁶			
7.4 x 10 ⁶			
4.2 x 10 ⁶			4.45 x 10 ⁶
3.9 x 10 ⁶			
3.6 x 10 ⁶			
1.1 x 10 ⁶		0.98 x 10 ⁶	
0.87 x 10 ⁶			
0.80 x 10 ⁶	0.80 x 10 ⁶	0.79 x 10 ⁶	
0.74 x 10 ⁶	0.62 x 10 ⁶		0.58 x 10 ⁶

a/ Daltons; size estimations were determined from a standard curve (full log; 3 cycles by 1 cycle) estimated by their mobilities relative (R_f) to the DNA standards included in the agarose gels.

sis var. sotto contained 1 giant extrachromosomal DNA element with a molecular size of about 23.5×10^6 daltons and 2 lesser elements of 0.80 and 0.62×10^6 daltons. B. thuringiensis var. finitimus harbors 2 giant DNA elements corresponding to $>50 \times 10^6$ daltons and two lesser bands with relatively small size (0.98- and 0.79×10^6 daltons). B. popilliae contained no giant extrachromosomal DNA elements but did contain 2 smaller elements corresponding to 4.45 and 0.58×10^6 daltons. This data is summarized in Table 3.

All nontoxic acrySTALLIFEROUS mutants that have been isolated lack the complete array of plasmids present in the wild type strains, implying a relationship between the presence of plasmid(s) and toxicity (Stahly et al., 1978). Similar evidence has now been presented by other researchers that plasmid(s) may be involved in the synthesis of the toxic parasporal crystals that are responsible for the pathogenicity of B. thuringiensis to insects (Debabov et al., 1977; Galushka and Azizbekyan, 1977; Ermakova et al., 1978).

Unfortunately, most of the described plasmids in bacilli are cryptic elements (Lovett and Bramucci, 1975; Lovett et al., 1976; Tanaka et al., 1977) lacking genetic markers and are unsuitable for selection of transformed colonies. Since little is known about the genetic functions of entomopathogenic bacterial plasmids they too are unsuitable for our use in development of transformation systems in these bacteria at the present time. However, the recent report by Ehrlich (1977) that several Staphylococcus aureus plasmids can replicate and express antibiotic resistance in B. subtilis was of great interest to us. Aside from their use for molecular cloning, these plasmids are also potentially useful for studies on plasmid biology, DNA uptake by competent cells, and genetic recombination in the bacilli.

Transformation experiments in our laboratory are being performed using the promiscuous S. aureus pUB 110 plasmid (Lacey and Chopra, 1974) which carries the kan^r/neo^r markers and is transformable and replicates as multicopy autonomous replicons in B. subtilis. It has been transduced between B. subtilis strains or transformed at a frequency of 10⁴ to 10⁵ transformants/ μ g DNA (Gryczan et al., 1978). We have also recently studied fifteen varieties of B. thuringiensis and the commercial strain of B. popilliae for their inherent antibiotic susceptibility/resistance to neomycin and kanamycin, markers to be used in plasmid and recombinant DNA transformation studies. Three varieties of B. thuringiensis were found to be doubly resistant, nine varieties were singly resistant (neo^r), and three other varieties were susceptible to both antibiotics (neo^s/kan^s). B. popilliae was susceptible to both antibiotics. One selected strain of B. thuringiensis was then transformed with the Staphylococcus aureus pUB 110 plasmid DNA carrying antibiotic resistance to neo/kan where it was expressed.

Attempts now will be made to develop a DNA transformation system for B. popilliae using the pUB 110 plasmid. Once developed we will then use this plasmid for so-called "shot-gun" DNA experiments by incorporating selected fragments of chromosomal DNA (generated by treatment with specific restriction endonucleases) from B. thuringiensis and sporulation genes of B. subtilis into the plasmid genome, followed by transformation into B. popilliae. The advantages of using the pUB 110 plasmid rests with the fact that it has a number of restriction cleavage sites ideal for our purposes. The restriction endonuclease cleavage sites on the S. aureus pUB 110 plasmid (Gryczan et al., 1978) are as follows: AluI-5, BamHI-1, BglII-1, EcoRI-1, HaeIII-4, HindII-2, HpaII-4, and XbaI-1. Restriction endonuclease cleavage site maps have also been constructed for the pUB 110 plasmid (Gryczan et al., 1978). In several cases other S. aureus plasmids (pUB101-Fus^r, pK545-Km^r, and pSH2-Km^r) may integrate in part or in toto into the bacterial chromosome and may be useful for integrating additional sporulation genes into the B. popilliae genome. In any event we will be using the XbaI, EcoRI, BamHI, and BglII restriction endonucleases for analyses and construction of the pUB 110 chimeric plasmids since they have been successfully used for insertion of foreign DNA without loss of the antibiotic resistant characters and do not interfere with its essential genes for replication (Gryczan and Dubnau, 1978).

Conclusions

The most difficult obstacle in our experiments has been the development of transformation systems in B. thuringiensis and especially B. popilliae. However, we have recently developed enriched media and conditions for maximum vegetative proliferation of B. popilliae. It is difficult at this time to assess the successful expression of desired genes in B. popilliae and B. thuringiensis to accomplish the ultimate goals of increasing pathogenicity, broadening the host spectrum, and obtaining in vitro sporulation of B. popilliae until the experiments are completed. However, because of the present state of knowledge, especially with regards to the genetics and molecular cloning achievements in E. coli and B. subtilis, we are predicting with reasonable certainty that tangible results with important implications for forage insect regulation will be obtained from these experiments.

TISSUE CULTURE TECHNOLOGY FOR DEVELOPMENT OF VIRUSES FOR PEST CONTROL

The second group of microorganisms for which development has reached the level of commercialization is the viruses. Three have already been registered with the Environmental Protection Agency. These are the nuclear polyhedrosis viruses (NPV) of Heliothis zea, Lymantria dispar and Orgyia pseudosugata. Among the several others being studied, the NPV of the alfalfa looper, Autographa californica, is the most likely candidate for early registration. This virus was the first to be discovered with a broad host range. In addition to the alfalfa looper, the virus is also pathogenic for the soybean looper, Pseudoplusia includens, the fall armyworm, Spodoptera frugiperda, the cabbage looper, Trichoplusia ni, and beet armyworm, Spodoptera exigua, all of which are pests to some degree on soybeans, as well as several other Lepidoptera.

A. californica NPV has been extensively tested for safety and for efficacy on lettuce, cabbage, soybeans and other crops. The molecular biology of this virus is being studied in many laboratories around the world and as a result it is the best characterized of all of the viruses being considered for biological control of insects. A petition for exemption from the requirement of a tolerance and for an experimental use permit is being prepared and will soon be submitted to EPA.

As with the three previous viruses registered for pest control, the present plans are to produce the virus in mass reared insects. Several problems are associated with such a production system. The most serious is the possibility of infection of the insects with a pathogen other than the desired virus. This is a serious problem especially in rearing Lepidoptera and to avoid it, requires good facilities and trained personnel. Even in a well run facility, the virus produced will contain contaminating saprophytic microorganisms and large amounts of insect protein and cuticle. This insect material can be highly allergenic to humans and could represent a health hazard to production workers, applicators and others who come into close contact with the product.

Production of the viruses in cell cultures is a way of overcoming these problems, and systems for the commercial production of vaccine against polio, measles, Marek's disease, and other vertebrate viruses have clearly established the feasibility of cell cultures for virus production. The lack of suitable lines of insect cells, the absence of knowledge about the physiological and nutritional requirements of insect cells in culture, lack of plant-scale equipment and the procedures for obtaining high virus yields with such equipment have prevented the production of these viruses in cell culture on a cost effective basis. Research directed at overcoming these problems has been conducted at the Insect Pathology Laboratory at BARC for several years.

Development of Cell Lines

Since the insect viruses are restricted in host range and will grow only in cells and tissues from insects, it is necessary to have cultures of insect cells to produce any of the insect viruses. Although the production of large scale primary cultures is possible with some vertebrate cells, the production of such cultures of insect cells is not possible because of the size and anatomy of insects. Therefore, continuously propagated cell lines are a necessity. Two such cell lines from the fall armyworm were developed and

TABLE 4.--Virus (NPV) yields from insect cell lines^{a/}

Virus	Cell line	Polyhedra per ml	Reference
<u>A. californica</u>	TN-368	1.92 x 10 ⁷	12
<u>T. ni</u>	TN-368	4.44 x 10 ⁷	2
<u>A. californica</u>	IPLB-1254	1.0 x 10 ⁷	Vaughn (unpublished)
<u>S. frugiperda</u>	IPLB-1254	1.24 x 10 ⁷	Vaughn (unpublished)
<u>L. dispar</u>	Mixed	5.8 x 10 ⁶	Goodwin (unpublished)

^{a/} from Vaughn and Goodwin, 1977

maintained in our laboratory for use in the study of the nuclear polyhedrosis virus from S. frugiperda, T. ni, and A. californica. These cell lines were developed from primary cultures of tissue from the immature ovaries of S. frugiperda pupae (Vaughn et al., 1977). They grow attached to the surface of the culture vessels which facilitates their use in many of the standard virological methods such as cloning and plaque assays. The virus yield from these cell lines compares favorably with the yields reported from a cell line from T. ni which is the other cell line used to produce the A. californica NPV (Table 4).

Large-Volume Culture Systems

There are two fundamentally different methods for culturing animal cells in large volume: 1) Cultures in which the cells are maintained suspended in medium usually by gentle stirring. 2) Cultures in which the cells grow attached to a substrate, usually the surface of the culture vessel. Insect cells will grow well in the suspension system (Vaughn 1968; Hink et al., 1974), however, some problems have arisen in using this method to produce insect viruses. The major problem is that infected cells have a much higher oxygen demand than non-infected cells (Strett and Hink, 1978). The vigorous bubbling needed to supply this required oxygen to cultures with a volume over three liters causes severe damage to cells with a resulting poor yield of virus.

We have avoided this problem in large volume cultures by using the S. frugiperda cell line which will grow attached to the surface of roller bottles (Vaughn, 1976). In this system the bottles contain a small amount of medium, and the cells attached to the surface of the bottle are slowly rotated through the medium and alternately exposed to the air in the bottle, thus avoiding the need to continuously aerate the medium. The cell growth in this system was equal to that in the standard flask culture system and cell yields of 3.5 to 4.5 x 10⁶ cells/ml of medium were obtained. The principle advantage of this system is the economy of space and labor obtained with the roller bottle cultures compared to flask cultures. For example, the amount of medium used in one 75 ml roller bottle is equal to that required for six plastic flasks. However, the surface area available for growth in the roller bottle is 670cm² compared to a total of 450cm² in six flasks. This advantage in

surface area can be further extended by using other bottle designs that have stacked discs or plastic coils inside. In some systems medium can be conditioned outside the culture vessel and perfused through the culture. Such culture systems are currently being tested.

Conclusions

Several systems have been tested and found suitable for the large scale culture of insect cells. There seems little doubt that insect cells can be grown in sufficient volume, utilizing the methodology developed for use in vaccine production to make the in vitro commercial production of viruses possible. The virus yields from the currently used systems average just over 10^8 polyhedra per ml of culture medium. With improved technology, the development of highly selected cell clones and improved protocols for their efficient use should give a 20-60 fold increase in yield. This achievement would make the cost of virus produced in cell cultures economically competitive with that produced in insects.

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NEAR-INFRARED REFLECTANCE SPECTROSCOPY FOR MEASURING COMPOSITION OF FEED

By Karl H. Norris

Near-infrared reflectance, NIR, has been accepted for measuring oil, protein, and moisture content of small grains and oilseeds. Most of the problems encountered in these applications are also present when we attempt to apply the same technology to animal feeds. The problems with animal feeds are much more complex, but the information gained in studies with grains and oilseeds can be applied. The work in our laboratory is directed toward identifying and minimizing the errors in NIR. The measurement of forages and feeds is not of primary concern in our laboratory, but the techniques we are studying have application to these products. We are characterizing the spectral reflectance properties of a wide range of agricultural products, and we are studying the parameters which affect these reflectance properties. In these studies we are concentrating on the sample preparation, the method of making the reflectance measurement, the optimization of data treatment, the selection of wavelengths to be used for a practical measurement, and the best method to minimize the errors.

Variations in particle size cause reflectance changes which can readily exceed the reflectance changes from the component to be measured. These particle size effects can be reduced by proper selection of wavelengths, but we have found that particle size effects can be eliminated by proper data treatments. The use of a ratio measurement of first or second derivative at two wavelengths can completely cancel particle size effects. By proper choice of the wavelengths for this ratio measurement, it is possible to minimize the effects of other parameters as well as cancel the effect of particle size. We have found that we can cancel the effect of sample temperature, moisture content, and particle size for protein measurement with a ratio of $d(\log(1/R_1))/d(\log(1/R_2))$, where R_1 is the reflectance at 2152 nm and R_2 is the reflectance at 2272 nm. With this ratio, a single-term measurement gives a correlation of 0.997 to protein content of wheat. A similar measurement gives a correlation of 0.995 to protein content of soybeans and with different wavelength selections, a correlation of 0.995 to oil content and 0.995 to moisture content.

Moisture is the easiest component to measure by near-infrared because the 1.94 μm water band is strong and carbohydrates, fats, and proteins present a minimum of interference at this wavelength. At least this is true for grains and oilseeds for moisture contents up to 20%. Above this moisture level, the 1.94 μm water band becomes so large that reflectance measurements become nonlinear. Moisture measurements of mixed-feed samples become more difficult if samples contain urea because the 1.98 μm absorption band of urea is very strong causing interference at 1.94 μm . Urea also interferes with the measurement of protein and oil, but by proper choice of data treatment and wavelength selection, it is possible to obtain single-term correlations of 0.993 for oil, moisture, and protein content of mixed feeds even when urea is present. We have also obtained correlations of 0.994 for nonprotein nitrogen on mixed feeds containing urea.

HAY-CROP SILAGE RESEARCH AT BELTSVILLE

By D. R. Waldo

Preservation of hay crops is required for winter feeding in most of the U.S. Animal production per day from preserved hay crops is a function of three factors: intake, digestibility, and energetic efficiency or feed conversion. Animal production per unit of land area is also a function of a fourth factor: recovery of available forage from the field and storage.

The proper description of factors involved in the transformation of forage into animal product requires use of the proper units of expression. Silage, or any fermented feed, has volatiles that are lost in conventional oven determination of dry matter or determination of organic matter following drying. Such losses cause an underestimation of true intake, digestibility, feed conversion, and recovery from storage but an overestimation of energetic efficiency. Such losses may be up to 14% of the true energy (Waldo, 1977). Unbiased energy data may be obtained by energy determination on undried samples of silage using polyethylene bags as primers or by a direct estimation of water.

Recovery of forage energy from the field is maximized by direct cutting and removal from the field. These direct-cut hay crops must be either dehydrated or ensiled. Ensiling direct-cut hay crops is known to decrease gains per day due to decreased intakes; milk production per day is not decreased as much as gain. Decreased recovery of direct-cut silage from storage decreases both gain and milk production per unit of land area. Experiments at Beltsville have demonstrated equal digestibility for untreated direct-cut hay-crop silages and hay of the same crop (Waldo *et al.*, 1969). In growth experiments at Beltsville, apparent feed conversion was markedly reduced by feeding untreated direct-cut hay-crop silages rather than hay. The use of 0.5% of 90% formic acid on a fresh basis when ensiling direct-cut hay crops increased gain per day by increasing intake and apparent feed conversion; milk production per day was not increased as much as gain (Waldo, 1977). The use of formic acid increased production per unit of land area as a result of increased energy recovery from storage. Direct-cut silage made with formic acid preserved 97% of the intake potential of the original crop in French experiments (Demarquilly and Dulphy, 1977). Formic acid is approved by FDA for use at 2.25% of pure acid on a dry matter basis. Its use in the U.S. seems limited primarily by economics.

The next research project attempted to resolve the apparent conflict between feed conversion data from growth trials and energetic efficiency data from calorimetry. The growth trial data showed apparent feed conversion was reduced when feeding untreated, direct-cut hay-crop silage but calorimetric data showed no equivalent change in energetic efficiency when feeding these silages. The initial factorial feeding experiments used untreated vs. formic silages with either no supplement, protein supplement, or energy supplement and showed protein to be the major factor related to apparent feed

conversions. Subsequent direct comparisons of feed conversions from growth trials and energetic efficiency from calorimetry with the same silages and supplemental protein resolved much of this apparent conflict. Protein degradation in untreated silage leaves inadequate dietary true protein for the growing ruminant and shifts some energy normally retained in its body as protein to energy retained as fat. This shift directly decreases weight gain because a larger fraction of the energy is stored as fat with a high energy concentration instead of as protein with a low energy concentration. This shift indirectly decreases weight gain because each unit of weight not retained as protein also decreases the weight of water retained by about three units. These compositional changes resolve the apparent conflict between feed conversion and energetic efficiency. This shift of energy retention from protein to fat has been confirmed by slaughter balance analyses. Thus, body composition of Holstein steers ranging in weight up to 375 kg was altered by improving protein nutrition using practical diets. The retention of nitrogen by balance techniques and the accumulation of protein by carcass analyses were positive linear functions of the insoluble protein intake where insolubility was measured in autoclaved rumen fluid.

The importance of insoluble protein must be investigated more generally as a major factor in the utilization of forages by ruminants. Protein degradation in the rumen is now being investigated as the next potential big advance in more efficient protein utilization by ruminants. The New Zealand finding (MacRae and Ulyatt, 1974) that protein entering the small intestine of sheep explained 62% of the improved growth when fed white clover as compared to ryegrass warrants further investigation of the general importance of true protein differences between legumes and grasses. Current projects are under way at Beltsville to more fully consider any differences in energetic efficiency between legumes and grasses.

The observed increase in protein accumulation in ruminants fed treated silages demonstrates the importance of minimizing protein degradation to soluble nitrogen during the ensiling process. Formaldehyde is more effective than formic acid for preventing protein degradation but formic acid is more effective than formaldehyde for preventing energy fermentation in the silo (Waldo, 1978). This suggests that some mixture is the ideal additive, nutritionally. It is also possible that this mixture may reduce the cost of silage treatment which is the major limitation on the use of formic acid. The primary objective of the present research is to gather data for the eventual FDA approval of formaldehyde as a silage additive.

The future objective of this work must establish the economic value of additives such as formic acid or formic acid-formaldehyde mixtures in relation to the losses and management uncertainties of other hay-crop preservation systems. Can expenditures on good silage additives be justified economically as an alternative to suffering the high losses of such systems as the large round bale? Silage additives require capital outlay but well-made treated silages certainly will produce more animal product per unit of land than large round bales. Both systems have similar low labor requirements.

Other remaining problems of treated direct-cut hay-crop silages are the handling and utilization of effluent. Silage effluent is now being stored for up to one year with formaldehyde and fed to ruminants or swine in Norway and

Northern Ireland. Direct-cut silage is more susceptible than wilted silage to freezing and this freezing becomes a problem in the Northern U.S. Freezing is probably best controlled by using horizontal silos with sides banked by earth.

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ENERGY METABOLISM

By P. W. Moe

The improvement in the efficiency with which forages and other feeds are used by animals has been a central goal of the Energy Metabolism Unit at Beltsville since its construction in the late 1950's. The objectives of early research were to detect the causes of lower efficiency of use of diets high in forages and to identify energy requirements of dairy cattle.

Experiments were designed to study the effects of level of milk production, proportions of concentrate, type of concentrate and type of forage on energy utilization by lactating cows. Among the significant findings of these studies were: 1) the utilization of metabolizable energy (ME), in excess of maintenance, for milk production is apparently unaffected by level of production (2); 2) the reduction in use of dietary energy at high levels of production is due to lower ration digestibility and ME value of the diets rather than decreased utilization of ME (4); and 3) the utilization of ME from different sources is not constant, but varies less (61-64% utilization of ME) for lactation than for fattening (3).

The results of these studies suggest that the major variables in the use of feed energy by cattle are: 1) reduction in ME value of diets at high intake; 2) partition of energy between milk and body tissue energy; and 3) variation in efficiency of ME for growth. Recent research has been concerned with the relationship between composition of diet and the rate at which ME value declines at high intakes. ME values of diets generally decline at a lower rate than digestible energy (DE) values with increasing intake because of a simultaneous reduction in methane production and averages about two percentage units decline in % ME per unit increase in intake equivalent to maintenance. The rate of decline in ME value is generally low with all forage diets and highest with mixed diets of forages and concentrates.

The partition of energy between milk and body tissue is influenced by dietary changes. At equal energy intake, an increased proportion of concentrate in the diet caused an increase in body fattening and decreased milk yield. A similar effect occurred when corn grain was substituted for beet pulp in the ration. The identification of the cause of this effect requires quantitative measurement of the end products of digestion.

The efficiency with which ME is used for growth has for several years been assumed to be directly a function of the proportions of volatile fatty acids (VFA's) absorbed from the digestive tract. Early experiments in Great Britain (1) demonstrated that infused VFA's with a high proportion of acetate were used with considerably lower efficiency than with a lower proportion of acetate. Since diets high in forage

generally yield relatively high acetate:propionate ratios and are also the diets generally found to have a lower energetic efficiency, the finding of relatively low energetic efficiency of acetate use seemed to be the explanation for much of the observed variation in energetic efficiency. Later experiments, however, suggested that in some conditions, acetate could be metabolized with much higher efficiency than that noted by Armstrong and Blaxter (1). In order to clarify the conditions under which acetate could be effectively utilized by ruminants, the Energy Metabolism Unit undertook a program of experimentation which centered around the metabolism of acetate. Initial studies demonstrated that the efficiency of acetate use could vary from about 30% on a high forage diet to 70% on a high concentrate diet (6) and that abomasal supplementation with glucose could restore the efficiency on a high forage diet. These studies clearly demonstrated that acetate in the presence of adequate glucose can be metabolized efficiently. The remaining problem is to identify the metabolic step in the utilization of acetate contributing to the inefficiency so that a strategy can be developed to overcome this inefficiency under normal feeding conditions with high forage diets. The pursuit of these answers requires new experimental approaches including the measurement of VFA production rates, pool sizes of key metabolites and other parameters in conjunction with calorimetric energy balance measurements. To facilitate these studies, equipment for measurement of radioactive gases in the chamber exhaust air system have recently been installed and calibrated (5).

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RESEARCH ON THE EFFECT OF HEAT ON FORAGE QUALITY AT BELTSVILLE

By H. Keith Goering

The most significant nutritional effect of heat applied to forage will be on protein utilization. Two major processes occur when protein is fed to the ruminant. Some forage protein breaks down in the rumen and is partially resynthesized into bacterial protein which is digested and absorbed in the small intestine, and some forage protein passes through the rumen without being degraded and is either digested and absorbed in the small intestine or passes into the feces. Additional heating of forage protein reduces the percentage of protein that breaks down in the rumen (Fig. 1).

Hay-crop silage. Analysis for crude protein fails to predict nitrogen available to the animal. Ensiling hay-crop as direct-cut silage doubles the soluble protein concentration. Improper ensiling of a wilted hay-crop may result in spontaneous heating and a decrease in protein availability. Wilted silages that have heated exhibit a decrease in nitrogen digestibility compared to wilted silage which did not heat in our research at Beltsville. Acid detergent lignin values were abnormally high for the forage that had heated or had been dried in the laboratory at high temperatures. Therefore, acid-detergent and pepsin insoluble nitrogen assays were developed to identify the severity of overheating (Goering *et al*, 1972). The relationship of acid-detergent insoluble nitrogen and pepsin insoluble nitrogen to protein digestibility was established to predict losses. Hay baled at high moisture may heat and result in a decreased protein digestibility. The incidence of heat-damaged samples was found to be greatly different among forage types (Goering *et al*, 1974). Heat damage is a problem in hay-crop silage and an occasional problem in hay, but not in corn silage. A minimum of 15%

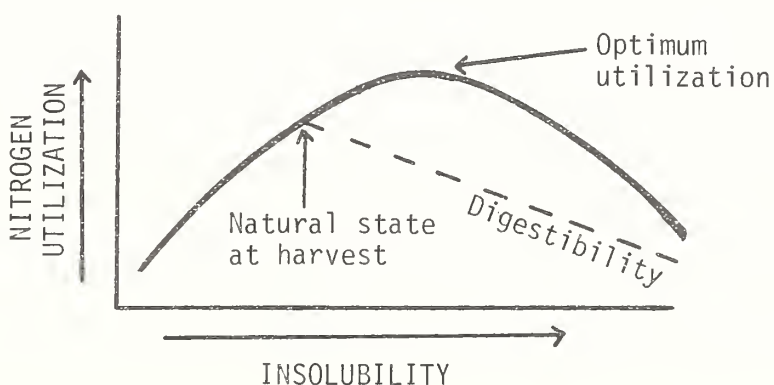


Figure 1. A generalized concept of the effect of protein solubility or degradability on nitrogen utilization.

digestible protein is lost in heat-damaged hay-crop silage based on the assay of surveyed samples, and 40% of all hay-crop silage samples were heat damaged. This loss represents 57,000 tons of digestible protein in the U.S. annually. The prevention of heating in hay-crop silages is dependent on rate of fill, consolidation, as well as dry matter concentration (Wood, 1971).

Using dehydrated alfalfa as a high percentage of the total diet for growing animals has given variable results. Further investigation suggested that heat damage was present in some dehydrated alfalfa used for these experiments. A series of experiments has demonstrated that prevention of overdrying would result in a product equal to or better as a protein source for ruminants than the product before drying. Heat damage exists in approximately 80% of the commercial dehydrated alfalfa samples surveyed (Goering, 1976). The estimated loss of digestible protein is 15% as a minimum. This loss represents 27,000 tons of digestible protein in annual production of dehydrated alfalfa in the U. S.

Research conducted at Beltsville in cooperation with other stations clearly indicates the important factors in dehydration are outlet temperature, final dry matter, and water concentration of alfalfa as it enters the dryer (Goering and Waldo, 1978). Other factors that have been studied and that will be receiving more attention in future research programs are control of final dry matter as the alfalfa exits the barrel of the dehydrator, water concentration of alfalfa as it enters the dryer (dehydrator) and the relationship of time and temperature.

Controlled drying can improve utilization by making the protein less degradable in the rumen, but excessive drying can reduce utilization by increasing the amount of indigestible protein in the feces. The application of heat increases the amount of plant protein entering the small intestine but too much heating produces insoluble protein which is also indigestible in the small intestine.

The use of heating to improve protein utilization has been studied in several experiments (Goering and Waldo, 1978). Dehydrated alfalfa, which had been dried at different temperatures, was fed to growing lambs in an attempt to show the positive and negative effects of heat with the same source of forage. The improved growth and nitrogen balance of some heat treatment was consistently demonstrated but was not statistically significant in these experiments. The experiments did indicate that there was no difficulty in avoiding heat damage of the protein during dehydration by keeping the outlet temperature at 150 C or less.

The importance of heat in forage processing to protein utilization by the ruminant animal will depend on the animal's need for protein undegraded in the rumen at a particular production stage. Alfalfa dehydrated at an outlet temperature of 150 C or less and a final dry matter percentage below 90% will probably not be heat damaged. Some heat in the ensiling process may be desirable but is impossible to control.

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ALFALFA BREEDING RESEARCH AT THE BELTSVILLE
AGRICULTURAL RESEARCH CENTER

By J. H. Elgin, Jr.

Diversification is a predominant characteristic of the Beltsville alfalfa breeding program. Concurrent efforts are directed at improvement in resistance to diseases, insects, and nematodes; development of tolerance to low pH, Al-toxic conditions; and demonstration of new breeding concepts.

The main thrust of the disease resistance work at BARC is breeding for improved resistance to anthracnose and Fusarium wilt. With the release of a number of anthracnose-resistant breeding lines in the early 1970's and the subsequent availability of several anthracnose-resistant cultivars, the anthracnose resistance research at BARC was greatly diminished. However, a new strain of Colletotrichum trifolii, which is highly virulent on our previously resistant elite breeding lines, was discovered in Maryland and North Carolina in 1978. Subsequently, a major breeding effort was begun to incorporate resistance to the new strain into our breeding lines. Preliminary observations indicate that a low level of resistance to the new strain is present in all lines.

Fusarium wilt has been known as a disease occurring on alfalfa in the warmer southern climates of the United States for many years. However, only the nondormant Southwestern U.S. cultivars and the northern adapted cultivar Agate have significant levels of resistance. At BARC, through a recurrent phenotypic selection technique, resistance to Fusarium wilt has been raised to above 80% in two alfalfa breeding lines adapted to the Middle Atlantic States.

Some entomologists rank the potato leafhopper as the No. 1 damaging insect on alfalfa. No cultivars with resistance to the leafhopper are available, although some cultivars resistant to leafhopper yellowing have been released. A major effort to improve resistance to the potato leafhopper was initiated at BARC in 1978. Laboratory rearing and screening techniques have been developed, and screening of large populations of adapted cultivars and experimental lines is presently underway.

The northern root-knot nematode was found in all fields sampled in a survey in Maryland and Virginia in the summer of 1978. Accordingly, a breeding program has been initiated to develop adapted populations with resistance to root-knot nematode. Comparative studies can then be conducted to determine the benefit of nematode resistance in alfalfa cultivars for the Eastern U.S.

For some time, Al toxicity has been believed to be a factor restricting alfalfa root growth in the acid subsoils of the Eastern U.S. Liming of the surface soils has little effect on the acidity of the subsoils. Screening of

Arc-related germplasm for tolerance to low pH, Al-toxic conditions has been conducted in the laboratory in acidic Tatum subsoil and in nutrient solution culture (pH 4.5 with 3 ppm Al) for four generations. Significant improvements in plant height, top weight, root length, and root weight have been demonstrated by the plants of cycles 3 and 4 of the Al-tolerant line when evaluated in nutrient culture. However, advantage of the Al-tolerant line under field conditions has yet to be shown. Field studies are presently underway.

Most disease and insect resistance in alfalfa is controlled by dominant genes. With the development of new strains with improved resistance to single disease and insect traits, new breeding methods to allow for complementation of dominant genes are needed. Strain crossing appears to be the most practical method. Studies at BARC are presently underway to investigate the use of strain crosses in the development of new, multiple pest-resistant lines and cultivars.

PLANT ADAPTATION TO MINERAL STRESS IN PROBLEM SOILS
(ABSTRACT)

By C. D. Foy

Forage crops, particularly those used for pastures, are often relegated to marginal land which may be steep, eroded, strongly acid and deficient in available nutrients. In such soils, mineral element toxicities (Al, Mn, etc.) or nutrient element deficiencies or unavailabilities (Ca, P, Mo) may seriously reduce crop yields. These growth limiting factors are not always economically correctable with current technology. But plant species and genotypes within species differ widely in tolerance to such conditions, and some of these differences are genetically controlled. Hence a promising alternative or supplemental approach is to tailor plants more specifically to fit problem soils. We need forage crop genotypes with greater tolerance to acid soils (Al-toxic subsoils), calcareous soils, saline soils, wet soils, dry soils, and even hardpan soils. Even on good soils, increased fertilizer efficiency is needed (particularly P and N) to conserve energy and fertilizer resources.

In our past approach to soil fertility problems we have emphasized changing the soil to fit the plant. As a result, many crop varieties have been developed under nearly ideal conditions of soil fertility and pH. Such varieties are like "incubator babies" in that they show little resistance to mineral stresses encountered in less than ideal soils. Examples are Sonora 63 wheat, developed in Mexico, and Gaines wheat (world yield record holder) developed in Washington State; both are extremely sensitive to Al toxicity in acid soils.

The objectives of our work in the Plant Stress Laboratory are: (1) identify present and potential mineral stress factors in problem soils; (2) screen plant germplasm to determine the range of stress tolerance available for manipulation; (3) collaborate with plant breeders in the selection and breeding of superior genotypes for specific problem soil situations; (4) determine the physiological mechanisms associated with differential stress tolerance; and (5) use physiological plant traits to refine screening procedures and improve soil-plant management practices.

Our work has emphasized plant tolerance to Al and Mn toxicities in acid soils. Significant differences in tolerance to both factors have been found within a wide variety of plant species. For details concerning our state of knowledge on the subject see publications on exhibit.

The merits of tailoring plant genotypes more specifically for adaptation to problem soils have only recently been recognized, even by the scientific community. However, within the last few years research teams of soil scientists, plant breeders and plant physiologists have been formed in several countries to determine how plant genetic variability can be exploited more fully in attacking problems of mineral stress in soils. A plant selection or breeding approach to soil fertility has several advantages. It is ecologically clean, energy conserving and may be cheaper in the long run than modifying the soil to fit our most exacting plants. Evidence that this

approach is gaining support is shown by an International Workshop (Plant Adaptation to Mineral Stress in Problem Soils) held at Beltsville in 1976, and an ASA Symposium (Crop Tolerance to Suboptimal Land Conditions) held at Houston, Texas in 1978. Proceedings for both symposia are on exhibit.

For more detailed information regarding current research on genetic-mineral stress relationships at Beltsville and elsewhere contact C. D. Foy (Plant Stress Laboratory, BARC) or one of the following:

- T. E. Devine - formerly alfalfa-Al studies, now soybeans-Al, BARC
- J. H. Elgin - alfalfa-Al tolerance, BARC
- J. J. Murray - (Turf) Bluegrass, tall fescue, fine leaf fescue - Al tolerance, BARC
- J. B. Powell - (Forage) Bermuda grass and others-Al, BARC
- A. J. Oakes - Introduced grasses-Al tolerance in acid soils vs. Fe requirement in calcareous soils, BARC
- P. W. Voigt - Weeping lovegrass-Al tolerance on acid soils vs. Fe requirement on calcareous soils, USDA, AR, Temple, TX
- Steve Baenziger - Barley and wheat-Mn and Al tolerance, BARC
- Austin Campbell - Acid soil (Al) tolerance of Amaranthus species and accessions, BARC
- A. L. Fleming - Physiology of plant adaptation to mineral stress, EARC
- J. C. Brown - Plant genotype-micronutrient relationships, BARC

FORAGE PLANT IMPROVEMENT FOR THE FUTURE

By R. L. Haaland

In 1901, Wilbur Wright told his brother Orville that man would not fly for another 50 years. In 1908, Wilbur had good cause to change his philosophy and said, "It is not necessary to look too far into the future; we see enough already to be certain it will be magnificent." These words very appropriately introduce the subject of forage improvement for the future. One need only look around the Southeast for a short time to notice that 60 to 75% of our land is either un- or under-utilized. This leads me to speculate that the future of forages and the livestock industry is bright. The future is up to us. As Napoleon Hill said, "What the mind of man can conceive and believe the mind of man can achieve."

The "South" has a rather deceptive reputation as a good winter habitat for man. The truth is we encounter many environmental phenomena such as high air and soil temperatures, high humidity, water shortages, mineral or pH problems, poor soil drainage, a severe pathogen complex and ad infinitum. This can put great limitations on forage germplasm. These problems are not without solutions; we simply do not yet have the solutions.

SOME BREEDING CONCEPTS OF THE FUTURE

Many different traits will be amended on forage plants of the future. The concepts I've covered are only some of the areas that could be improved.

Seedling Vigor

If a plant can survive the seedling stage it has already surmounted several of the adversities it will encounter in life. Improved seedling vigor in both grasses and legumes will allow earlier planting and more assurance of stand establishment. Resistance to soil heaving and earlier grazing are excellent examples of advantages of good seedling vigor. Another possible advantage may be in assisting longevity of stand. Seed of vigorous species dropped in a sward will help perpetuate the species. This advantage could apply to pure stand hay fields or pasture renovation where legume species are introduced into grass swards.

Root Systems

Plant breeders usually concentrate their efforts on top growth characteristics. We often forget that the root system is a vitally important part of the plant and being underground is exposed to different stress conditions than top growth. Improved root systems will be forthcoming. We will find more extensive root systems, roots that break hard pans, that selectively take up minerals and tolerate low pH soils, and roots that will tolerate pathogen, heat

and water stress. Efforts to improve root systems should also include efforts to improve the various symbiotic phenomena found between plant roots and nitrogen fixing microorganisms. Screening plants for specific root exudates may be routine in the future. Efforts to improve root systems will lead to development of unique new screening techniques and root evaluation systems. Certainly the understanding of rhizosphere ecology of forage systems will be enhanced.

Multiple Pest Tolerance

Forage crops, like all crops, have numerous pathogens representing several genera and species that will reduce yield, stand and quality. It is not my intention to say which pests should have priority in a breeding program, instead I will express my opinion on how to tackle the pest problem. Multiple pest tolerance using horizontal (many gene) resistance rather than single gene vertical resistance will give the best long term results. We dare not play the gene-for-gene resistance game that has been popular with soybean and wheat breeders. This approach often puts selection pressure on the disease organism which may mutate to an even more virulent strain. Both annual and perennial forage crops need broad genetic based tolerance systems to best meet the diverse pathogen complex of the South.

Area of Adaptation

Efforts to expand the area of adaptation of several forage species are taking place in several breeding programs. When high-quality bermudagrasses are moved into Kentucky and high quality cool-season perennial species are moved to Florida, forage production in both areas will have better seasonal distribution. The economics of beef production in the South would be changed in a positive direction.

Quality

Forage quality has been a major effort of several southern breeding programs. The USDA program at Tifton, Georgia, has been in the forefront in developing warm-season cultivars with improved quality. High quality bermudagrasses are no longer in the distant future.

Cool-season grass quality, particularly that of tall fescue, remains a perplexing problem. However, some new ideas being generated on the role of loline alkaloids and possible mycotoxins from fungi living inside fescue could well lead to some remarkable breakthroughs in the future.

Forage Production

Large amounts of forage can be produced in the Southeast during some parts of the year; however, at other times low forage supply can be the main limiting factor in livestock production. The thrust for forage breeders should be to develop cultivars that will have good forage production during times of limited supply such as winter. More reliable forage yields will help stabilize the livestock industry.

Seed Production

The final phase of forage breeding is to insure adequate seed supplies of improved cultivars. With a concerted effort by breeders and forage agronomists, seed production will be improved in forage crops. Furthermore, seed will be produced in the Southeast to improve the economics as well as supply aspects of the forage seed industry.

Expanded Uses

Forages are going to expand in importance. They will regain some of their stature as conservation and reclamation crops, they will be developed to be more compatible with no-till farming, and will be used to meet special water conservation needs. New forage crops will continue to be introduced to the Southeast, adding to the ever growing list of 'non-natives' that have found a home in the South.

CONCLUSION

The most challenging aspect of the future of forages is that it depends on all individuals involved in the forage-livestock industry. Scientists, extension workers and producers will share in this dynamic sculpturing of tomorrow. I suggest we use as a guide the words of the great philosopher Pierre Teilhard de Chardin, "Our duty as men is to proceed as if limits to our ability did not exist; we are collaborators in creation."

FORAGE MANAGEMENT: A LOOK TO THE FUTURE

By R. S. Kalmbacher

Our lack of precision in predicting the future is no excuse to remain silent because we have a responsibility to livestock producers to look ahead through the use of hard data or other kinds of evidence to make certain that we aren't on a collision course with the future. Perhaps it is more important to be imaginative and insightful when dealing with the future than it is to be 100% correct. Even error has its uses especially if I can challenge you toward constructive thought, which is my goal.

How far should we extend ourselves into the future of forage management? To go too far would mean that our anticipations would avoid reality. At the other extreme our predictions could be too short-sighted such that research to cope with potential problems could become continually flustered by present day change. The "right" distance in time examines and evaluates alternatives of action before the need for a final decision. Our outlook into the future of forage management will cover the span of the next 20 years, and that is really the near future.

Certain things will not change because they are basic characteristics of the southeastern region. The potential for cattle production will remain great, due to the long growing season and "ample" rainfall. There will be a large southern acreage which will remain as a livestock feed source, because it is less suited for production of crops used by man or other animals. There will continue to be seasonal shortages of forage because rainfall and temperatures will be limiting at certain seasons, although it's safe to say that the future holds improved forecasting of storms, freezes, droughts, etc., which will help avoid disaster. Additionally, there will be a demand for beef, although there may be less consumption per capita with higher cost.

However, forage crop management will undergo drastic changes that will be forced on us by shortages in energy and water, human population pressures, inflation etc. Since limitations in energy from shortages of fossil fuels are most eminent, this may have the greatest impact on forage management in the next 20 years. Energy affects all phases of livestock production: nitrogen fertilizer, machinery operation, transportation, pesticide production, irrigation, and other management tools. Since U.S. agriculture uses only about 3% of the total U.S. energy demand, even a substantial reduction by agriculture will have a limited effect on the total consumption, but conservative use could substantially reduce the cost of agricultural products. If current use patterns continue, fuel costs will increase five-fold by the year 2000 (4). Just how well we recognize the shortage and design a plan of action to live with the problem will be a record of our imagination and resourcefulness as forage crop scientists.

Nitrogen fertilizer and legumes

Increasing shortages of fossil fuels result in decreasing availability and increasing cost of commercial nitrogen fertilizers. This is especially critical for forage producers in the southeast where it apparently requires more nitrogen fertilizer per megacalorie from forage than in any other area of the U.S. (5).

Reduced availability to livestock producers may result for two reasons. First, large quantities of ammonium nitrate, etc. may not be available for widespread pasture application. Such nitrogen may go into complete fertilizers for grains, vegetables or other "higher" value crops. Secondly - however remote - is the possibility of government regulation restricting allocation of commercial nitrogen into crops intended for export to offset cost of energy importation.

In the next 20 years forage producers may not be able to afford the amounts of nitrogen they presently apply. Agricultural Statistics (1) indicated that prices received by producers for livestock (meat) increased 69% between 1967 and 1975, while prices for fertilizers increased 117%. This may be a small biased example from the past, but when "experts" predict that if natural gas (upon which anhydrous ammonia production depends) usage continues at 1972 rates our domestic supply will be exhausted in 11 years, then there is little doubt that forage producers will need to pay even more exorbitant prices for nitrogen.

What can forage agronomists do about the fertilizer problem? First we can begin to look more realistically at the design of our forage management work involving nitrogen fertilization. How can researchers realistically test varieties, measure effects of defoliation, establishment, or cattle performance or investigate any experimental factor when we have been applying fertilizer at rates of 300, 400 or even 600 kg/ha? It's doubtful that management developed with such fertilization practices will be valid in the future. It is imperative that forage managers look for "optimum" nitrogen rates which can be used in management studies. Most forage scientists today were trained to produce maximum yields, and any material that could increase yield could be used regardless of cost. In the next 20 years forage managers may be faced with more extensive management with less nitrogen fertilizer.

The grass species we are already using should be evaluated on their ability to produce with less nitrogen. Annuals that are high nitrogen users such as ryegrass, small grains, millets and sorghum x sudangrass hybrids may not have widespread use as they have had in the past. They should be de-emphasized, and perennials that do not have to be re-established and tolerate lower fertilization levels should be favored.

The relative efficiency of nitrogen use by perennial grasses should be examined. One method to index grasses may be to look at the ratio of the percent change in yield to percent change in nitrogen rate. In an example from Hodges and Martin (7) UF-4 stargrass (Cynodon nlemfuensis) produced 14.5 metric ton/ha with about 300 kg/ha of nitrogen and 20.2 ton/ha with 600 kg/ha of nitrogen or a 39% increase in yield with a 100% increase in nitrogen, thus a ratio of 0.39. Pensacola bahiagrass (Paspalum notatum) produced 10.9 and 13.4 metric tons/ha with 300 and 600 kg/ha of N, respectively or a ratio of 0.22. This means that a 50% reduction in nitrogen may result in a 20% drop in stargrass yield but a 10% drop in bahiagrass yield. Perhaps some of the more efficient nitrogen users should receive greater emphasis in research programs.

At present, high nitrogen levels are necessary just to maintain some desirable grass species in the sward. Management based on an understanding of the ecological relationships of desirable forages and weeds must be substituted for indiscreet nitrogen application. Except for limited situations, forage grasses requiring excessive nitrogen rates for stand maintenance can best serve future cattlemen by remaining a part of a plant breeder's collection.

Perhaps a scale of relative competitiveness among forage species needs to be developed. Photosynthetic efficiency, leaf area index, water and fertilizer efficiency, rate of growth, method of reproduction, for example, can be quantified and related through mathematical modeling which describes the system. Forage agronomists can't conduct fundamental research on the entire system, but components of the system can be studied and put together to explain what happens.

The use of less energy-intensive nitrogen sources should be evaluated. These include animal, industrial or municipal waste. About 50 kg of N can be supplied per year by the 9,000 kg of manure produced annually by one cow, or two fattening beef cattle or 84 chickens (10).¹ The energy investment to spread this on one hectare would be $860 \text{ MJ}\cdot\text{ha}^{-1}$. The total energy cost of production of 50 kg of ammonium nitrate requires $3050 \text{ MJ}\cdot\text{kg}^{-1}$. Even without considering cost of application of the ammonium nitrate, there is substantial savings in energy and money.

Experimentation with time of nitrogen application is important to increase the efficiency of the forage system. Forage agronomists must identify times when temperate or tropical grasses promptly utilize nitrogen for the production of high quality feed.

Nitrification inhibitors have shown promise for improving the efficiency of nitrogen fertilizer use in the corn belt (9). Considerable increases in the efficiency of nitrogen use could be realized in the humid southeast by maintaining nitrogen in the ammonium form.

Slow release nitrogen fertilizers such as urea-form or sulfur-coated prills, etc. have been uneconomical in the past. Their potential for providing more conservative use of nitrogen will be the same in the future, but if ammonium nitrate costs \$300 per metric ton perhaps then the cost of their manufacture could justify their use.

Increasing dependence on legumes in the future is essential because of their ability to fix their own nitrogen and provide needed forage quality. Forage breeders must furnish the perennial legumes that are needed in the southeast, and researchers with management ability will have to develop principles to establish and maintain them. The principles must be based on a study of the ecological relationships of the grass-legume mixture.

Less energy intensive methods of legume establishment will be advantageous, and sod-seeding appears to have potential. Smith and Evans (11) found that about $1365 \text{ MJ}\cdot\text{ha}^{-1}$ more energy was required for seeding by conventional methods rather than a sod-seeder ($1727 \text{ MJ}\cdot\text{ha}^{-1}$ vs. $362 \text{ MJ}\cdot\text{ha}^{-1}$, respectively). However, widespread use of sod-seeding in the southeast is limited by a low probability of success in establishment. In order for the practice to become a reality agronomists must fully recognize problems in establishing legumes in grass sods, then look for solutions to the problems. Major needs include: identification of the most successful legumes for interseeding; knowing how much light is required to establish different legumes under a grass canopy; recognizing allelopathic relations if they exist; identifying the seedlings'

pathological and herbivore pests; determining the importance of rapid and effective legume inoculation; recognizing the seedlings' nutrient and water requirements for establishment. This is only a partial list of the needs. Notice that machinery and herbicide evaluation have been deliberately left out. Herbicide and machinery use are important, but they are solutions to problems, and to begin a research program with their widespread evaluation can be a case of the tail wagging the dog.

Herbicides add an element of environmental risk, and they require energy to produce. Paraquat and glyphosate require 460 and 454 MJ·kg⁻¹ to produce, respectively. The grazing animal, normal haying, and mowing operations should be the number one tool in reducing grass competition or destroying the habitat of seedling pests in the establishment phase of legumes.

Research on maintaining legumes for longer periods must be concurrent with establishment efforts. If disease is a major problem, then forage managers need to team-up with a pathologist. Perhaps legume species' rotations will minimize pathogen build-up. Managing plants to maintain a morphology which produces a micro-climate that is least conducive to pathogens may also be feasible. Certainly enlightened management which stems from an understanding of the conditions that favor legumes is worth working toward.

More forages - less grain

Grain will have a higher world-wide priority as a human food. Finishing cattle as we do today may be prohibitive because cattle are the least efficient of all livestock in converting grain into human food. For each kg of protein produced from cattle about 9 kg of grain must be consumed. Additionally, the cost of finishing cattle on grain in the southeast may be economically unfavorable when alternate markets for the grain are considered.

Forage will substitute well for grain especially in lighter cattle which are less efficient. In an example by Brokken (3), calves weighing an average 20 kg less than yearlings required 39% more grain than yearlings. Yearlings, marketed at 45 kg less weight than 2-year old cattle, required 8% more grain than 2-year olds. Forage-fed cattle will be older when marketed and lower in carcass grade at slaughter.

To substitute forage for grain, our forage management must: increase the rate of consumption and energy intake; increase forage production (with less energy input); and improve harvesting, processing, preserving and feeding of forages.

Before the task of increasing forage digestible energy intake can proceed, all members of the forage-livestock team need to further develop the technology necessary to obtain a reliable and workable procedure for the measurement of intake by the grazing animal. Without intake estimates agronomists and animal scientists will suffer from the loss of a valuable tool for evaluating forage management.

Digestible energy intake can be increased through management for immature grasses and legumes. Growth regulators which postpone or prevent forages from entering into the reproductive phase would prove advantageous. Everyone is familiar with the drop in quality with increasing plant maturity.

More efficient use of the digestible energy in forage crops could be obtained by more sensible matching of cattle nutritional requirements with pasture quality. At 90 days after calving, cows could be put on pasture which provides maintenance energy. This introduces the concept of first and second

grazers described by Blaser (2). Calves can top-graze legumes or immature grasses first through a creep grazing technique after which cows can graze the remains. Stockers may benefit from such a system by grazing before cows.

Less energy intensive systems which allow for the preservation of surplus, high quality forage merit considerable effort. From harvest to feeding, silage systems require about one half the labor, but twice the energy of hay systems (8). However, the less energy intensive hay system generally results in greater losses than a silage system. It is estimated that 28% of the total production of a hay crop is lost between cutting and feeding (6), which demonstrates that research which minimizes losses should proceed at the same time.

Organic preservatives for conserved forages may help reduce losses and maximize the value of production. Different approaches to application which are more effective at preservative distribution among the forage material are needed. Microbiologists and agronomists have a lifetime of opportunity in manipulating the beneficial and harmful microflora of hay and silage. Poor quality, low digestible hay or other by-products of agriculture might be inoculated with specific strains of fungi which result in a better finished feed. Such forage would be digested in vitro in a "rumen" before being consumed and digested in vivo by cattle.

Micro-wave drying of hay or solar drying in the lower south should be considered. Practical application of such work may have to wait for technological break-throughs in engineering, physics, etc. which will make the hardware available, but fundamental research could proceed with today's knowledge and a little imagination.

Ensiling of quality surplus forage will probably be more popular, especially in areas where hay making is difficult. As forage managers we can facilitate the ensiling process of tropical grasses which are low in water-soluble carbohydrates by exploring mixtures with plants high in fermentable energy. Perhaps sugar sorghums interseeded in Cynodons would add - not necessarily to the yield but to the fermentable carbohydrate at maturity.

Forage managers must strive to simplify management for the producer, while minimizing the chance of failure. We need to keep in mind that practices requiring investment in specialized equipment may hinder rather than help. Interest rates increased 303% between 1966 and 1977 (1). Operations utilizing the equipment that producers have on inventory is preferable.

The future holds tremendous challenges, and forage managers will have to make some changes in order to meet those challenges. The "cut, dry and weigh days" of forage management are gone forever. Of course there must be applied research, but for real progress we must explain why as well as what occurs when treatment affects are measured.

Since problems don't come neatly packaged we must work as a team with other disciplines. Forage management will meet tomorrows needs if today's agronomists choose their problems wisely and measure those parameters that allow the scientific community to build principles.

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MAJOR INFLUENCES ON UTILIZATION OF FORAGE BY LIVESTOCK IN THE FUTURE

By Hagen Lippke

The precipitous decline in cattle prices in 1973 brought about a renewed awareness of the need to better utilize the great forage potential of the southern U.S. for the production of beef. The issues involved were thoroughly explored in the Southern Regional Forage-Fed Beef Research Workshop in 1975 (1). This paper will comment briefly on important changes since 1975 and how they might influence the cattle industry.

External Factors

The price of fuel energy, and particularly petroleum, will weigh most heavily on our economy in the years ahead. High fuel prices will act in two ways to reduce cattle production. First, the cost of nitrogen fertilizer, if not offset by the introduction of legumes, will reduce forage supplies unless demand for beef and, consequently, beef prices are strong. Demand for beef will probably weaken, however, because it is directly tied to the general state of our economy, which is expected to decline under the pressure of rising fuel costs. Beef imports and meat extenders will also reduce the demand for domestic beef.

These same economic forces should reduce the relative amount of grain fed to beef cattle and sheep. The reduction in arable land available to agriculture and the increase in human consumption of grain due to population increases will also reduce grain supplies to livestock. The impending production of 'gasohol', while taking from grain supplies, does yield a by-product which cattle can utilize.

In a worst case situation, the grain available to livestock would be fed to dairy cattle, followed by poultry and swine. Beef cattle and sheep would return to the role of scavenger that they have occupied for almost all of history. However, meat production under these circumstances could still be quite high if the knowledge gained through research is fully utilized.

Internal Factors

Increased nitrogen fertilizer cost has encouraged a rising interest in utilizing legumes. Those species presently adapted to the southern U.S. are most useful in mixed swards under grazing. Management to maintain legumes in combination with grasses and to control bloat are potential problems that may need attention from both education and research.

The shift toward legumes will improve the overall quality of forages and can, therefore, increase animal performance. Total meat and milk production may not increase, however, since the dry matter yield of legumes is lower than the well-fertilized grasses they may replace.

During the recent liquidation phase of the cattle cycle, increased forage utilization, to the point of finishing cattle on pasture, was regarded an important tool for economic survival by cattle producers in the Southern Region. The inability to provide finished slaughter animals year-round was pointed up as the primary deterrent to development of a 'forage-fed' beef industry. Two developments are changing that situation.

First, the definition of finished is shifting toward a leaner carcass due to consumer preference for leaner beef and the increasing demand for hamburger. Under the unique market situation today, a 'good' grade carcass has the same value as a 'choice' carcass and neither is valued as highly as a 'bull' carcass.

Secondly, forage breeders have brought the goal of year-round supply of slaughter cattle within striking range. Cattle gains on the best-quality bermuda cultivars now available are high enough to require relatively little grain feeding for finishing (2). Further improvements in the quality of warm season pastures can undoubtedly be made through continued breeding research and the addition of adapted legumes.

Assuming development of high-quality warm season pastures, two critical gaps in forage production remain in year-round, high-performance, grazing systems - drought and cold temperature. Irrigation can, of course, alleviate drought conditions. But it can also guarantee early establishment and growth of cool season forages to bridge the cold weather gap. Obviously, the returns must be high to justify the expense of this kind of insurance.

Even though research may soon clear the biological obstacles to forage-fed beef, there remains a technology gap between confirmed research findings and generally adopted forage management practice much greater than in many other segments of agriculture. Within 10 years this technology gap may be the obstacle to progress in forage utilization.

SUMMARY

In total, the major influences on forage utilization in the southern U.S. will increase the relative amount of forage consumed by livestock, and animal performance on forages will improve. This presumes a continuation of research efforts to improve quality of warm season grasses. A major increase in legume research is needed. A concerted effort by both research and extension workers must be made to transfer forage management technology to the user.

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TRANSFER OF FORAGE TECHNOLOGY TO THE PRODUCER
IN THE FUTURE BY EXTENSION

By J. Kenneth Evans

Introduction

Some of what I shall say today is a matter of record. Some is based on my experiences and experiences which have been communicated to me by individuals in this audience. Some of what I shall say is my own opinion. You may dislike and/or disagree as you wish, but please do so only after you have evaluated your own activities. If you are offended by anything which is said, please consider the fact that you know much more than I about your own activities and programs. My remarks are impersonal and may strike a tender nerve, of which only you are aware.

I make no apology for requesting that we each examine ourselves! I got mad at myself several times as I prepared for this meeting.

My assigned title uses some terms which should be defined: transfer, technology, and producer.

Transfer: "(verb) To convey from one place, person or thing to another; transport, remove or cause to pass to another."
In our context, to transfer is to communicate.

Technology: "Applied science" or science which can be applied to the solutions of problems.

Producer: "One who produces, brings forth or generates. One who grows agricultural products"...(1)

Technology

Let's begin with that which is to be transferred - the technology. Those of you who conduct research are, by definition, producers of technology. You produce what we in extension are supposed to transfer to producers. Traditionally you have produced good information on relationships between biological, physical, and environmental phenomena. When you plan your research do you consider soils? Forage crops? Forage consuming animals? Weather? Do you research individual practices or total systems? Producers use individual practices as parts of systems which they must manage.

Do you consider people? How many of you devote as much thought to how your research relates to producer problems as you devote to design of the experiment for statistical treatment and publication of data? How often do you consider how your research can contribute to a better life for people? Do you obtain economic data? If people use information from your research, will it produce income or will they have to subsidize the practice with money they need for something else? Tax-supported research must consider the people who pay taxes as the ultimate objective of the research or the tax support will stop! An increasing number of researchers do not have farm backgrounds, therefore they do not have a good understanding of producer problems. This fact, plus specialization of researchers and the need for systems research, demands cooperative research. Accelerating costs of production demand more careful economic considerations.

Producers

I am grateful to those who selected the titles for choosing to say "producers"--not farmers. There's nothing wrong with the word farmer, but the definition of a farmer is changed at the discretion of the Bureau of Census. There is no specified size or volume of business required for one to qualify as a producer.

Who are the producers? The profile is changing and we are not properly considering the changes as we develop technology and educational programs. We write and talk at length about the fact that farmers are decreasing in number and increasing in size of operation. Are producers decreasing in numbers? I'm convinced that they are increasing and rapidly!

There are tremendous numbers of people who are moving to rural homes on one or five acre lots. These people may have a horse, a few cows or calves and know very little about managing the animals or pasture. They may want to supplement their income or they may have moved to the country looking for a better place to live. Whether they are concerned with economics or aesthetics, they pay taxes and they have votes. We must feel an obligation to provide information for them, just as we do for farmers! Yet there are some of you who see these folk as a nuisance, keeping you from your work with those farmers who produce most of the food.

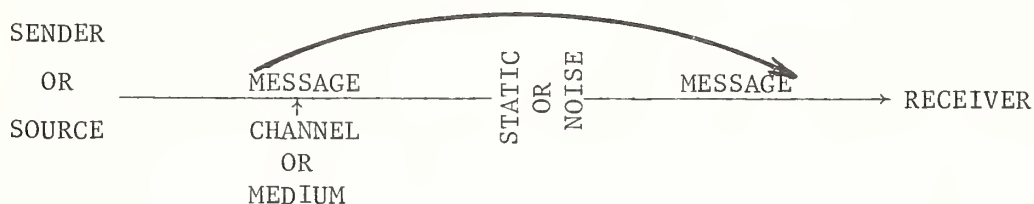
In addition to these rural residents (who aren't defined as farmers) we have an increasing population of part-time farmers. Programs for development of small industries in small towns and rural areas have increased opportunities for off-the-farm employment. One study shows over 80% of those surveyed in one area of Kentucky working 100 days or more off the farm. The same study shows 38% of beef herds are less than 20 cattle and 81% of herds were less than 50 (2). These farmers are usually interested in farming for profit, but they have problems and life styles which differ from full-time farmers. I find a tremendous increase in the numbers of professional men and women who are active in both management of and work on these farms. They may be highly educated, but know very little about farming. They may have very little formal education.

How about those farmers who are decreasing in number and getting larger in scope of operation? They produce most of the food. They are really commercial agriculture. Are we providing information of value to them? Much of our work has been with members of this group or at least the top end of the group - because they have been good cooperators. Many members of this group are finding themselves in a real cost - price squeeze - particularly those who are carrying heavy debt loads for land, machinery and operating capital.

They must be concerned with economics of practices, systems and alternatives or they will not survive.

Transfer

As stated earlier, to transfer is to communicate. How do we communicate? Let's first look at the communications model and then apply the model to examples of attempts at communication.



This communications model shows a sender, a receiver, a message, and a channel or medium through which the message is to be communicated. Any static or noise may distort or block the message and prevent accurate receipt or interpretation. We must plan the communications process so as to bypass the noise.

Examples of attempts to communicate

1. Researchers of the past (senders) attempt to communicate with us today. The channel they choose may be a journal, research report, or bulletin. Some examples of noise could include: (1) their report, improperly written, cannot be understood; (2) the library doesn't have the report; (3) the ego of the intended receiver causes him to feel his idea is so good that no one else could possibly have been so brilliant; thus no attempt is made to find any previous work. Result - the message was not received and valuable time is invested in rediscovery.
2. Producer (sender) wants to communicate a problem to a researcher (receiver). The channel selected is a county agent or extension specialist. The message may be received and research either conducted or found in the literature which solves the problem. Noise may interfere. Some examples of noise are: (1) the attitude of the extension specialist - message may not be transmitted; (2) the attitude of the researcher (that's no problem--what does a producer know about research needs? OR that extension specialist is a pain in the donkey. He is always trying to find more work for someone else to do. OR any fool should know the answer to that question).

Result - the message was not received or was received and ignored. Badly needed research is not done.

3. Researcher (sender) wants to communicate a message to producers (receivers). The channel selected is an extension specialist. The data (message) are summarized and given to the extension specialist. The specialist then becomes the sender and he selects the appropriate channel for transmission. To whom should the message be sent? Is it for all producers or a selected group? What channel should be used? How should the message be worded?

How can we effectively communicate?

As channels we traditionally have used individual consultation, method and result demonstrations, bulletins, circulars, leaflets, radio, television, movies, and meetings. Unfortunately, except for individual consultation, little attention has been devoted to using channels and wording selected for specific receiver groups. In other words, we have been shooting with a scatter gun. Changes in producer profiles indicate that we must aim more specifically.

Channels must be selected to which specific receiver groups are tuned. Wording must be used which our receivers understand. If meetings are used, they must be held at times convenient for those who work an 8-5 job and do their farm work evenings and weekends.

New channels need to be developed. The experimental Green Thumb Project started in Kentucky is an attempt to do this. "Black boxes" will be developed for attachment to the television sets of the audience. Producers will be able to dial access to computers which will display on the television screen information which is requested.

Old channels need to be used differently. A recent study in New York revealed that both radio and television are considered by farmers to be very poor sources of information. Printed media (flyers, bulletins, etc.) were considered most valuable by 60% of those surveyed. Reasons given were the availability of printed material for re-reading and future reference (3). An Ohio study showed television extremely effective when it was used as part of a planned educational program (4).

Individual consultation remains the best way to help people with specific problems. Public programs will never have enough personnel to provide such individualized service on a broad scale. In the past we have worked with a few leaders closely and relied on the chain of practice adoption to spread the word (5). Private consultants who provide individualized service on a fee basis are spreading into all parts of the country. Integrated pest management programs at universities are beginning to provide pest information to subscribers. We must consider ways in which we can communicate current research information to these consultants.

Agribusiness has for many years been influential in determining what producers buy. We must devise methods to educate this group with latest

research findings and not try to deprive them of their right to engage in free competition.

Vocational agriculture teachers need more technical support than they presently have available to them. Their contacts with researchers, Extension Specialists and other professional specialists must be increased if they are to provide current information for their students.

COUNTY AGENTS have been and will continue to be a key link in our chain of communications with producers. Extension specialists must stop running the roads and prepare more educational materials for use by County Agents. County Agents must begin to think of themselves as educators rather than "arrangers" or coordinators. The energy crisis may force us to reduce travel. If it doesn't, we need strong administrative support when we say NO to a County Agent who will call our department chairman or dean when he can't get a specialist out to his county for a meeting.

Conclusions

Researchers must be sensitive to problems and needs of specific producers if new technology is to be of value to producers. Consider these needs as research is planned. Producers will not be receptive to technology which they cannot use in their situation. Neither will they continue to provide tax support for generation and transmission of such information. This does not mean abandonment of basic research efforts. In most cases immediately useful information can be obtained at the same time basic research is conducted - if the researcher is tuned to problems.

Those who attempt to communicate technology to producers must remain constantly aware of the process of communications. You may have an excellent technological message, but if you choose a channel to which the receiver is not tuned, you fail to communicate. Likewise you fail if your message is worded in a code which is not understood by the producers you are trying to reach.

We who are in extension must use old methods more effectively. For example TV may be equipped with special devices to access computers or special courses may be planned for use in educational TV channels. Correspondence courses may be developed even for college credit. Classes may be taught at "odd" times which fit specific groups of producer schedules. Information updates may be provided to agribusiness through newsletters, courses etc. Vocational agriculture teachers should be in some way included in professional improvement programs.

If extension is to transfer technology to producers in the future there must be applicable technology available to help people solve problems. There must also be a viable extension service. It is our responsibility to maintain the high quality of information which future taxpayers feel is worthy of their support.

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MARKETING OF FORAGE PROGRAMS IN THE FUTURE BY INDUSTRY

By Warren C. Thompson

Down through the years, industry has built its marketing and sales programs almost entirely on making the public aware of their new and tried products. But something new is being added. The total program concept, to make the public aware of the new products and how these products fit into an ongoing program, is the new marketing look taken on by industry. Each year more and more companies are developing marketing systems to sell the advantages of products. So, marketing programs in agriculture are changing.

Those of us who are concerned with developing aggressive marketing programs are constantly looking for more dramatic, more meaningful and even new approaches to reaching the buying-using public. There are developments that appear to be new, but when analyzed thoroughly, they really point to more refinement and perhaps extended services that can be applied to the individual situation with the innuendo of more yield, longer life, and higher profit potentials.

The quality of inputs and the investment in preparation for and the execution of marketing programs through research and development have increased and will increase substantially in the years ahead. As we look to the future, here are some of the developments we can expect in the seed industry.

Research: Some of the country's top plant breeders are working in the private sector. The investment that industry is making in research continues to grow. The quality of research that is being done and is being forecasted is growing even faster. With the advent of the Plant Variety Protection Act of 1970, giving 17 years of privacy to developers of a variety, research at the industry base started to soar and then industry really had reasons to make firm commitments to long-term programs.

In the seed industry, this research has been and will continue to be built around the plant breeding group. But in these days, these scientists are looking far beyond plant breeding per se for the development of new varieties. They realize that farmers are looking for varieties with more disease and insect resistances, but they also realize that they are looking for plant materials that will withstand poor levels of management yet respond to excellent management. They are looking for varieties that will survive low fertility levels, yet will respond to high fertility. They are also looking for varieties and species that will combine to solve specific problems, such as water erosion, bloat, limited life span, etc.

In the years ahead, we can then expect the plant breeders at the private level to expand their investigations beyond germplasm development to include work with the plant-soil management level. For it is not until the total approach is understood and communicated that farmers will be able to achieve the continuing (year after year) yields that scientists see in their plot work. For the future we wonder how many plant breeders will try to find out how much mechanical and management-related abuse a new alfalfa variety, for instance, can stand and still survive. For instance, cut it early in the

spring and then every 20-25 days, reduce fertilizer or stop it completely, cut the crop 15-25 days before the normal historic freeze date, drive a heavy tractor and loaded trailer of hay over it eight to ten times during the year, drive a tractor across it twice while it's wet, apply 50 tons of liquid manure per acre each winter, etc. These and other farm practices ought to be looked at and will be included by some of the braver ones in the years ahead.

Research and educational work with the public sector will increase at an increasing rate. As more specific varieties and lines are developed, there is need for more detailed evaluation under farm conditions. And who knows better than the local and state extension staff where the best sites are located to fully test products and programs? The initial work will be done at the private base or bases. But this work will need to be supplemented by scientists, including extension workers, at the many public facilities and on farmer-owned farms located throughout the country to further determine adaptation and expected results. Industrial interests cannot afford to own the property or provide the staffing of the many locations needed to fully wring-out these materials and see how they best fit into the forage programs for each area. So they must seek the help of the public sector to get the full picture.

The plant-animal relationship, its function and response to new products, will have to be based in the public sector. At this point, I do not know of one seed firm that has a full-time ruminant nutritionist and the facilities to look at this type of work. Yet, to fully understand "new" species, new varieties, mixes, and their place in farming takes at least a working knowledge of the animal responses that can be expected.

This work will be funded by grant programs and be coordinated by the scientists involved, both private and public. This type of teamwork can do nothing but help develop sound forage and animal production recommendations that will be profitable to farming.

These are but a few, yet some of the more important, developments that we will see from research. For only as there is top-flight research conducted will there be the base for the total program approach with excellent plant materials and resulting program. The present design of the growing seed concerns has to be on profit, and none should consider profit without profit to farmers. The research has to be good, or the new materials break apart. That's why industry is so careful with releases, wanting, always wanting more information on their product prior to and during entry into the market.

Now let's take a look at some of the segments of marketing programs of the future. Here we will see re-entry of the time-proven methods. But with the sophistication of the better communication systems, the effectiveness should be expanded and enhanced.

Demonstrations have been used for generations as a prime teaching tool. Demonstrations are used basically "to show research results, clear recommendations under farm conditions and look for problems not found in small plot research." When they are carefully located with a top farmer and in a central location that is easily accessible and are well maintained and labeled, they quickly show the value of a new practice, program, and/or product. No teaching tool has yet been devised to speed the adoption rate and improve professional efficiency and recommendation confidence better than demonstrations. And as long as they are kept simple and properly labeled they can be

monitored and understood easily by farmers without the presence of a professional.

The use of demonstrations will likely be expanded both in numbers and scope. Also, we will see more used as the base for training agri-business and agency personnel, as well as being used for farmer field days and for extending local publicity.

In the seed industry, demonstrations are used primarily to show new varieties under ideal seeding, fertility, and harvest conditions. They are also used to show seeding rates, weed control, insect control, whatever it takes to put a whole program together. Five major reasons for demonstration failures are: 1) too many sites that are not fully maintained, 2) located where the public cannot see them, 3) poorly labeled, 4) poorly managed, and 5) located on non-forage land. All of these problems can be solved, however, with patient planning and top, locally involved leadership.

Some of the most effective demonstrations have been multi-acreage in size, even whole farms. These units must be simple with very few, preferably two, treatments and not replicated. They must be properly managed to produce the full value of the program or the idea. Then, farmers start talking more tons of forage, pounds of beef, pounds of milk, and dollar value. No group has more to gain with good demonstrations or lose with poor ones than industry. That's why we see more care taken each year to develop displays.

In-depth training for the local representatives is expanding rapidly. The product "authority" to the farmer has to be the company's representative. If he is well informed about the product and the research program that produced it and gets the feel for the way the product will fit into the local situation or program, he will properly represent it.

So much time and thought goes into the development of workshops, field days, and research exposure to distributors and dealers. The future dictates an expansion of these programs to reach directly to the farmer. For the most part this training will be handled at the local level by dealers and distributors using teaching aids supplied by the parent company supplemented with material from the local area where possible. Print material is constantly being developed to fill this need.

The money spent for advertising has increased dramatically in the past few years. The type of advertising has also been altered. In the print media, especially regionalized magazines, it usually appears in color and preferably ties as close to the area as possible. In TV it is a matter of early exposure and attention-getting to announce a breakthrough of a new product. We realize that programs need to be in print so that farmers can study them. Radio is very much the same as TV--to get the idea across and usually at the local level, where the product can be purchased.

The dollars going into advertising are growing each year, far beyond the rate of inflation. Industry knows, based on many studies, where farmers get their information for new practices, products, and programs. Two of the leading sources are popular agricultural magazines and the local dealer. So obviously, this is where much of the advertising dollar is invested.

The use of industry publications varies from company to company and year to year. Some companies believe more strongly in their use than others. At North American Plant Breeders we feel real strongly about our forage publications. We produce basically four types: 1) Product identification.

2) Program education. 3) Growing guidebook for all products. This presently is a color, 24-page comprehensive product and program brochure. It is designed for the dealer and his salesmen, county agents and their associates, and top farmers. 4) A seed product guidebook, an expensive, color, three-ring notebook type that contains all of the current advertising and educational materials. It also contains technical materials. It is designed only for distributors and their key salespeople.

As to the future, we see publications as our showroom and we will continue to expand the number and quality, and constantly attempt to improve the content. We feel that this is the best place for us to use our own data and the data of scientists in the public sector, and where adaptable, allows us to expose excellent work across political boundaries.

Editorial exposure in the public press has come to the forefront in recent years and shows real promise for the private as well as the public sector. These writings, without advertising, usually tell a story of how a new program or product is working for a farmer or farmers. We in industry prefer that these articles be prepared by the editorial staff of that book or paper.

These are some of the important components of the current and future forage marketing program by industry as I see it and project for the immediate future. The one area that will be the prime base will be the local team approach, industry and the public sector working together. To all of our representatives, we encourage a strong relationship to all other sectors, private and public, serving agriculture, to build a strong forage program. We know that when there is that strong forage-meat-milk program, farmers will profit and so will all of us. We cannot do it all alone and have the kind of success we are committed to help farmers achieve.

THE SOUTHERN LIVESTOCK BUSINESS IN THE FUTURE FROM A PRODUCER'S STANDPOINT

By Walter Stephens

Gentlemen, I feel it a great personal honor for this opportunity to share with you one small producer's view of the immediate and long term future of the cattle/forage industry.

I feel a sense of inadequacy, for there is a good possibility that much of what I say may include research already in progress, or research, completed and published and in long time service. If this is the case, I plead ignorance and apologize for repetition of that with which you are familiar. Finally, I commend you for the monumental work which you, as a group, have already completed and further, for your understanding of the needs and problems related to marketing forage through animals.

I believe, as you, that the cattle industry, not only in the South, but the entire nation, boils down to one simple business venture -- forage production. We're involved in producing plants which merely happen to be carried one extra step and marketed through herbivores.

Dr. Earl Butz, former Secretary of Agriculture, once said that all agricultural productivity is geared to one six letter word -- PROFIT...and I would take the liberty of adding additional three letters... NET.

Agricultural productivity is not geared to how much volume is produced per acre -- not how much grain can be produced, not how much tonnage of hay or how much TDN or how many crops annually -- but to how much net profit that acre of dirt will produce after being moved and sifted around, fertilized, planted, watered, tended, harvested, and then fed to animals.

In achieving a net profit, I believe that in the high rainfall areas of the South, we're faced with special problems today; I believe these problems will be multiplied manyfold tomorrow -- land costs and annual input costs. Land costs are due in part to speculation and in part to competition from directly consumable row crops. Annual input costs are due in part to the inherent low fertility, low organic content of most of our land and in part to the high temperature, high rainfall levels with which we're blessed.

We'll dismiss land costs briefly, yet constantly return in viewing forage needs.

In South Georgia, you often hear of farms that have sold for \$700/acre and you immediately envy the lucky scoundrel who stumbled on this bargain. Yet, review a soils map and you usually find that 50% of that farm included open cultivatable land of class one or two -- and the other 50% was cut over timberland that is perhaps too steep for anything but a forest or pasture or too sandy or too eroded. This poorer land will then cost another \$100/acre to clear and reforest or \$200-250/acre to clear and lime and put into pasture. The buyer can allow 50% of this farm to be reclaimed by natural flora, fauna, reptilia -- brush, deer, rattlesnakes -- and demand that the better land pay

for itself and its poorer brother. If that is the case, the usable land of the farm now costs \$1400/acre. Another option: reforest the land and wait 13 years or more for the first dividends from pulpwood and a second dividend five or more years later. Under this scheme, the farmer now has the original \$700 purchase price plus \$100 for reforestation and, if no principle is paid until the first timber harvest, at 9% interest, he has a total investment of \$1736/acre. Our forests will not generate this sort of revenue.

So for the final option: spend \$200/acre to stump, rake, burn, pick, lime, establish pasture, and delegate cattle as custodians of the property.

This is the route that our people are presently taking. But this is hungry land. It demands a good diet of lime, it drinks nitrogen. It does not like to produce a high quality product that we can market through our animals and achieve the elusive net profit goal.

In the South, I believe that it is this land -- the eroded clay land, the sandy droughty country or the grey sand of the lowland Coastal Plains, toward which animal forage research must be directed.

I believe that each experiment station should carefully survey this very basic -- the soil -- in its area of jurisdiction. I believe that grazing forage research of the future -- with notable exceptions of high yield grain type forages -- should be concerned with profits on soils that are good for nothing but a cow.

The agricultural South, and especially Southeast, is predominantly row crop country. Generally our herds are smaller -- when cattle prices are low, we liquidate more excessively than the rest of the nation and turn our attention to other crops. An exception to this is Florida.

In Georgia, the average herd numbers 25 head. The bovine is a necessary scavenger on most farms. Its domain is the good soil only after peanut, soybean or grain harvest and then it serves as a gleaning machine. During winter it adds weight and drops its calf and suckles briefly on lush winter annuals and then in February or early March, it is again driven back to its lair of deep sand or clay hills. There it will remain, expected to produce a 500-550 pound weaning calf, rebreed and complete its only obligation to the farmer -- to return a net profit. There it produces a 350-400 pound calf, has a 75% conception rate, and fails to pay the interest and principle on the now \$900/acre land. Given the cow as a necessary evil on most farms, I believe that most southern and especially southeastern herds of the future will fluctuate primarily in numbers of feeder and yearling age cattle rather than mature cows. I believe the number will depend on the near term market outlook -- will it be more profitable to sell as a weaner or to hold over for a few extra months and sell as a yearling. The decision to hold and sell more weight is also partially determined by what is on that poorer land; whether or not that forage will continue to grow that weaned calf, how much expense will be involved and how much competition there will be for cropland.

I took the liberty of asking the Board of Directors of the Georgia Cattleman's Association what, in their opinion, was the greatest need in forage research for the Southland. Their statement was a perennial high quality grass - a grass more digestible than our present popular grasses -- more nutrients per acre rather than tonnage alone. Tift 44, according to research may be one of the answers... 20% more in every respect than Coastal. If it is not an answer, perhaps it is a step in the right direction.

Yet, when I mesh this need with my own thoughts, I'm still concerned... concerned about net profits. Tomorrow, I'm afraid that I'll be even more concerned because of one abundant element -- nitrogen. Today, nitrogen costs

approximately 20.3 cents/lb. spread by our local dealer. Within the past three months we've come to realize that once again we're confronted by an energy shortage -- if not a shortage, certainly an increase in energy costs. As petroleum increases in cost, natural gas will likewise follow suit. According to a South Carolina extension publication, it currently requires 38,000 cu. ft. of natural gas to produce a ton of ammonia and even more to produce Urea and Ammonia nitrate. When basic natural gas increases in cost, we can likewise expect each segment of the production and merchandising chain to require additional revenue.

While nitrogen costs are a major factor in cattle production in the high rainfall south, in the future we're faced with another problem; machinery and the energy required to power it.

So visualize this -- within three years fuel costs double, machinery costs increase 30% and nitrogen fertilizer costs 35 cents/lb applied. Where then, does this leave the Southeast? The West country, Texas, Montana, Wyoming will feel the effect and will grumble but will suffer little.

Let's trace the nitrogen hypothesis in a practical application. Today, for grazing purposes, most of us are probably applying 150 pounds of N/acre or \$31. Within three years this increases to \$52.50 plus something additional for P & K and lime. At that time, cattle prices may have peaked and the farmer will be forced to closely monitor expenditures. What then will we do with this high quality grass that is almost wholly dependent on man for any significant N input? When a farmer cannot realize a net from a cow, why should he produce regardless of the tonnage 150 pounds of N might enable the grass on the poorer "40" to yield... Why produce if it costs more to feed the grass than the cow will return?

Again, we have several options: sell the cow, fallow the inferior land and transfer the responsibility of payments to the better soils and let them do double duty. Or fertilize less and let the cattle starve while we're hoping that this is not really the beginning of the slump. Or sell half the cattle and fertilize less... or select another plant or combination of such which not only will provide grazing at a time when we need it but also will provide something for the grass that follows.

In my opinion, grass, cattle and man have a symbiotic relationship wherein each gets something material from the other and yet depends on the other... but that relationship is wrong. I feel that man should be more parasitically inclined: he should be at the top of the chain -- a near parasite who provides little in the way of material or much management and who harvests the entire fruits of the lower chain members. I feel that the key to open the lock and free man into a world of euphoric parasitism or near parasitism -- is the legume; is a combination of legumes; is a relationship between legumes and grasses.

I feel that the legume, whether it be clover, wild peanuts, alfalfa or a combination or others, is the future of the cattle industry in the entire high rainfall South.

You have already done admirable work on legumes and legume combinations -- from my own experience paramount among this is work with the varieties of arrowleaf clovers -- but more work is needed to prepare for the day of 35 cents/pound nitrogen.

PLANT 1. WINTER ANNUAL OR PERENNIAL LEGUME.

And what should this legume combination do?

FIRST... It should be easily established in sod. Now, look at the dirt and where is that sod? If I had my own selfish way, the expertise of you gentlemen would be marshalled for a direct attack on the low, sandy, wet soils

of the Southeast, soils that are adept at breaking farmers who've tried to grow corn or beans on them -- the lands which, were they not in pasture would make good hiding places for deer and other critters... But that's one person's viewpoint... other areas have equal problems with the red soils and eroded lands. But the legume must be suited to these areas and no single legume will be sufficient.

SECOND... Beyond being easily established in sod for one year, it must have enough seed and be vigorous enough so that it can reseed itself with some success even in heavy bahia grass cover and can withstand extended dry periods during the fall.

THIRD... The winter annual, for my area and much of the Southland, should begin growth in August, should have a flush of growth in the early fall, produce some grazing by November 1 and sufficient growth for extended grazing by February 15.

FOURTH... Because of grazing and other cultural practices, the plant would best reseed subsurface.

FIFTH... The plant should fix sufficient nitrogen subsurface and not as mulch, to provide 1/3 to 1/2 of the N requirements for the grass which will follow.

SIXTH... The winter annual should support intensive grazing at least until May 15.

SEVENTH... It should flower close to the ground or at least be able to flower and reseed without cattle removal.

EIGHTH... It should exhibit either resistance or tolerance to insect defoliation during the early growth stages.

NINTH... This plant or combination should be palatable to cattle, should have small tendency to bloat and of course be highly digestible.

PLANT 2. SUMMER ANNUAL OR PERENNIAL LEGUME.

FIRST... The summer annual or perennial legume should reach production about the time that the winter annual is on the decline -- say around May. It should continue such production for 90-120 days and then reseed and become dormant during August or September.

SECOND... The rhizobia of this plant should continue to function in the presence of 50 pounds of N (man applied), and should furnish 1/3 of the N requirements for the grass with which it grows.

THIRD... It should be able to exist well and reproduce under constant grazing or mowing conditions.

FOURTH... It should be resistant to any buildup of nematodes in the soil.

PLANT 3. HIGH QUALITY SUMMER PERENNIAL GRASS.

FIRST... High quality

SECOND... Sufficiently open sod to enable the establishment and perpetuation of legumes.

THIRD... Sufficiently deep rooted for drought tolerance and winter hardiness.

FOURTH... Should have a growing period beginning in April and extending through September.

FIFTH... Should have sufficient hardiness to withstand close grazing and haying conditions.

SIXTH... Should have comparable P and K requirements to make it compatible with summer and winter legumes.

In summary, I feel that the future will continue to see the high rainfall areas of the South, except Texas and Florida, not as the cattle capital of the country, but very much as today -- regions in which cattle are sidelines.

Cattle, with the possible exception of stockers, will continue to be delegated to the poorer, less usable lands until grain and peanut crops are harvested. At that time they will be loosened on the fields to glean crop residues.

Under the hoped-for future situation, more cattle could possibly be held to heavier weights and marketed direct for slaughter off of forages produced on the poorer soils.

Future farming operations will continue to evolve around the seasons and soil wherein, during early fall, the majority of the better lands will be planted in soil-retaining nematode-discouraging winter annual cover crops. Now the cattle, again, will be transferred back onto permanent pasture lands of dormant grass stubble and emerging winter legumes. During this time, the calves are weaned and receive a diet of young legume, supplemented with grain. Dry cows will enjoy the poorer pasture-legume mixtures and hay supplement. The calves will begin to drop during late November and early December. By December 1, winter annuals should be of sufficient height for lactating brood stock, replacement heifers and stockers to graze.

In late February or early March, primarily all cattle will again be transferred back to the legume/grass areas and there be rebred. By April 1 or later, the winter annual legumes will have flowered and produced seed under constant grazing conditions; the warm weather legume/grass mixture will be in full production. This production will continue throughout the spring and summer until, again, the cattle are removed to clean cropland.

By February-April, the steers are 15 months old; they have gained within 25% of their genetic potential, as measured by feedlot performance, or about 2.3 pounds per day, and will have done this on forage alone. They will weigh 1035 pounds each and will grade high, good or low choice. The better end will be slaughtered for cut beef and the lower end, for hamburger.

In addition to providing a net profit, they will also provide a welcome additional cash flow at a time when other farm resources are tied up in row crop production.

I believe that excess forage cut for hay should contain a portion of legume. I believe that only for a brief span during a year should a cow consume legume deficient forage..... I believe that calves must have a choice of legumes in their diets throughout the year except during the late summer and that this source of energy and protein should then be replaced partially by grain..... I believe that in the day of 35 cents/lb nitrogen, that plants must become self-sufficient and should primarily supply nitrate needs for themselves. I believe that for the foreseeable future, we will have a supply of phosphates, potassium and lime..... I believe nitrates to be our limiting factor in the South in the future.

Finally, the cattle operation I see in the South fits well with the row crop scheme. The cattle, here as in the West, will continue to be delegated the land fit only for a cow. Man's input will be 50 pounds of nitrogen plus appropriate P & K and minor elements and lime and management. And for this he will expect virtually year round grazing on high quality forages and these forages under average conditions will enable a steer to weigh 1,000 pounds at 14-15 months of age. And for the management and his input, the farmer will expect his poorer soils to carry an average of one cow unit per acre; he will expect these soils to produce a combination that will yield a 'net profit' yet will not compete with his better soils either for time or crop nor rely on them to pay an unfair portion of the farming investment.

It has been a pleasure to speak with you. Again, I salute you for the monumental work already done with legumes and grasses as well as high yield

grains and silage. And finally I apologize if much of what I've said is repetition of already gained knowledge, but I believe that if the cattle business is to survive and perhaps segments to increase in the high rainfall South, we must develop ways to increase the net profit realized by manipulating our poorer, otherwise nonusable soils.

We must develop better ways of cooperating with the elements wherein nature furnishes more raw material and man furnishes more brainpower, less fossil energy and ways wherein, by trimming raw material input, man's final cut will be greater.

NATIONAL INFRARED REFLECTANCE RESEARCH PROJECT ON FORAGES

By W. C. Templeton, Jr., and J. S. Shenk

BACKGROUND

Following the pioneering research of Karl H. Norris on use of near-infrared reflectance technology (IR) for assessing quality of grains and oilseeds, a research project to determine the utility of IR in quality evaluation of forages and feedstuffs was initiated at University Park, Pa., in June 1975. From its inception the research has been a cooperative undertaking by Pennsylvania State University and the U.S. Regional Pasture Research Laboratory, with J. S. Shenk as leader. Estimated total expenditures on the research to the end of FY 1978 are in excess of \$350,000.

The table on the following page summarizes University Park research relating IR data to several chemical analyses and sheep data.

IR research on forages is in progress, also, at BARC, Richard B. Russell Agricultural Research Center, University of Florida, Louisiana State University, Michigan State University, New Mexico State University, and, perhaps, at some other U.S. locations.

Discussions were initiated in early 1978 to explore the need for and feasibility of a national research effort to further test and validate usefulness of IR for determining forage quality. A proposal to initiate such research was developed at University Park and sent to R. F. Barnes, March 30, 1978. At a planning meeting at University Park, November 8-9, 1978, it was agreed by representatives from eight locations that the proposal was a feasible approach to accomplishment of much-needed research and that such a cooperative project, compared to conducting research on an individual-location basis, offered a number of advantages. Expressions of interest in participation were confirmed by each of the locations, and William C. Templeton, Jr., was elected Project Coordinator.

PRESENT STATUS AND OBJECTIVES

Six locations were later identified for participation in the national project. Five are designated Cooperating Laboratories (CL). They are Beltsville, Md.; Athens, Ga.; El Reno, Okla.; St. Paul, Minn.; and Logan, Utah. University Park will serve as the Principal Laboratory (PL). Funding of the project is accomplished, and NER procurement officials are in the process of obtaining six computerized, high-precision near-infrared reflectance spectrophotometers for initiation of the research. Instrument delivery by November 15 is anticipated.

Objectives of the project are to:

1. Develop and test computer programs which provide continuing advances

Table.--Summary of correlations between laboratory analyses and sheep data and predicted results using infrared reflectance.

Factor	Forage ¹	Corn Silage	Grains ²
Organic Analyses			
Protein	.96	.92	.98
<u>In vitro</u> dry matter disappearance	.89	.75	.90
Acid detergent fiber	.94	.88	--
Neutral detergent fiber	.97	.83	--
Lignin	.94	.83	--
Cellulose	.95	--	--
Dry matter	.95	.94	.96
Acid detergent insoluble nitrogen	.86	--	--
Pepsin insoluble nitrogen	.84	--	--
Mineral Analyses			
Ca	.85	--	--
P	.84	--	--
K	.77	--	--
Ca/P	.88	--	--
B	.84	--	--
Sheet Data			
Intake	.85	--	--
Digestibility	.96	--	--
Digestible intake	.92	--	--

¹A wide variety of forage species and mixtures of species.

²Grains included in this calculation include corn, barley, oats, and wheat.

in data processing and mathematical treatment of infrared data to maximize prediction accuracy;

2. Further define and measure plant, environmental, and other factors contributing to variation in infrared prediction of chemical composition and animal response;
3. Define the fundamental bases for the infrared reflectance spectral properties of forages as related to their chemical and physical properties;
4. Test the usefulness of infrared reflectance in forage breeding, forage management, and animal-utilization research programs; and
5. Produce, analyze, assemble, and maintain selected forage samples in a reference library for use in IR instrument calibration and other forage-evaluation studies.

Each of the locations will conduct research related to one or more of the objectives.

CONCEPT AND PLAN OF WORK

Research will be conducted through an integrated, coordinated program involving scientists at the six locations. The PL will have primary responsibility for development and support of computer programs to control and collect data from the IR instruments, add chemical data to the IR files, remove and add IR data to the files, process IR data and select wavelengths, statistically analyze data, and develop other programs to handle specific problems and needs. Studies will be conducted in conjunction with CL's to evaluate new data processing and wavelength selection programs as they are developed. The PL will provide training required to operate the instruments.

Research at CL's will focus on effects of forage species, environments, fertility, locations, years, maturity, preservation, and sample handling on IR spectra, and on chemical and in vitro analyses of forages. Particular attention will be given to elucidating the chemical and physical inter-relationships between forages and their IR spectral data. A major effort will be made to obtain sheep and cattle response data on limited numbers of samples at each laboratory.

All locations will conduct support analyses for ongoing research programs in plant breeding, forage-management, and animal-utilization research. Initial system programs from the PL will be used to calibrate each instrument with chemical and/or in vitro data from the CL's.

A sample reference library will be maintained by the PL, with support of the activity by CL's. Samples used in instrument calibration will be included in the library, and information, including IR spectral data from the PL, will be stored on magnetic tape or appropriate media. The reference samples will constitute calibration sets for IR instruments not part of the system and for other uses in forage-evaluation research.

SUMMARY

Subsequent to promising results from exploratory research employing near-infrared reflectance for assessing forage quality, a national research project, involving six locations, is being established. Procurement of computerized high-precision near-infrared reflectance spectrophotometers is planned to allow further validation of the technology and to elucidate the effects of chemical composition and such factors as plant species, environment, state of maturity, preservation method, and sample preparation on spectral composition. Emphasis will be placed, also, on relating IR data to animal derived data in forage-quality measurements. A forage-sample reference library will be established and maintained at University Park, Pa.

Insect Resistance in Alfalfa:
Present Status and Future Possibilities

By Roger H. Ratcliffe

INTRODUCTION

Alfalfa serves as a host plant or habitat for a large number of insect species. App and Manglitz (1972) reported that over 100 species have been recorded as injurious to alfalfa. Included among this array are approximately 20 species that are generally considered of economic importance in the United States because of their feeding injury to foliage, roots, or seed producing portions of the plant. In addition, there are many insects that feed on alfalfa, but are usually too scarce to cause economic damage; others which are incidental visitors or may be feeding on other plants scattered among the alfalfa; and those which are beneficial, such as predators, parasites, and pollinators.

Because of this large complex of insect species present in alfalfa there is much to be gained by use of selective control procedures, such as plant resistance, which can be directed at the target pests with minimum impact on non-target species. It is not surprising then that more than 60 alfalfa cultivars with resistance to one or more of 6 insects have been developed and released over the past 22 years, and that a strong research effort continues in this area today. In the past, this research has been directed primarily to suppression of the most serious pests regionally or nationally, as would be expected. More recently, efforts have been directed to development of resistance to insects which are considered to be of less economic importance, but as a group, may be of greater importance in reducing yield and persistence of alfalfa than often thought. This would include insects such as the clover root curculio, alfalfa blotch leafminer, and various plant bugs.

Sorensen, et al. (1972) provided a good review of progress in breeding for insect resistance in alfalfa. They included in their review information on the nature and stability of resistance, general concepts in breeding for resistance, and techniques for isolating resistance, as well as discussion of resistance to specific alfalfa insects. Those desiring further information on these various aspects of insect resistance in alfalfa are referred to their paper and references which they cite. This presentation will be limited to a brief review of the progress made to date in development of insect resistant alfalfa cultivars and consideration of the principal areas in need of further research. I have used the review by Sorensen, et al. (1972) extensively in drawing together this information and some specific references which they cite are listed.

PRESENT STATUS OF INSECT RESISTANCE IN ALFALFA

I have listed the more important insect species attacking alfalfa in Table 1 according to the portion of the plant attacked or principally affected by feeding. These include many of the species discussed by App and Manglitz (1972) in their review of alfalfa pests. I have also indicated the relative importance of the pest on alfalfa and whether or not alfalfa cultivars have been developed and released for the particular insect. It is obvious from the information in Table 1 that the greatest success in developing resistant cultivars has been obtained with insects feeding on alfalfa foliage. Among this group of insects the greatest progress has been made in developing resistance to aphid species. Much less research has been

TABLE 1.--Principal alfalfa insect pests grouped according to the major portion of the plant attacked

Insect	Importance	Resistant Cultivars <u>1/</u>
<u>Foliage</u>		
Alfalfa blotch leafminer	Major <u>2/</u>	No
Alfalfa caterpillar	" <u>2/</u>	"
Alfalfa weevil	"	Yes (T)
Egyptian alfalfa weevil	" <u>2/</u>	No
Blue alfalfa aphid	"	Yes
Pea aphid	"	"
Spotted alfalfa aphid	"	"
Meadow spittlebug	"	" (T)
Potato leafhopper	"	" (T)
<u>Roots</u>		
Alfalfa snout beetle	Major <u>2/</u>	No
Clover root curculio	"	"
White fringed beetles	Minor	"
<u>Flowers and seeds</u>		
Alfalfa seed chalcid	Major	No
Plant bugs (<u>Lygus</u> and <u>Adelphocoris</u> spp)	"	"
Stink bugs	Minor	"
Thrips	"	"

1/ T - Tolerance is principal mechanism of resistance.

2/ Present or damaging in a limited area of the U.S.

conducted on development of resistance to root feeding insects, due in great part perhaps to the difficulty in working with subterranean forms. Also, no resistant cultivars have been developed for insects that reduce seed production, although considerable research has been conducted on development of screening techniques and evaluation of germplasm for resistance to the alfalfa seed chalcid and Lygus species, particularly L. hesperus (Nielson, 1967; Nielson and Schonhorst, 1967; Nielson, et al., 1974).

Significant progress has been made in developing and releasing alfalfa cultivars with resistance to the blue alfalfa aphid, pea aphid, spotted alfalfa aphid, alfalfa weevil, potato leafhopper, and meadow spittlebug. A partial list of resistant cultivars is shown in Table 2. The greatest success has been achieved in developing resistance to the spotted alfalfa aphid, where more than 40 cultivars have been developed and released since 1957. Much of this success resulted from the development of suitable greenhouse techniques for mass screening and clonal testing of alfalfa germplasm. Although new biotypes that are capable of attacking previously resistant cultivars have been reported, entomologists and breeders are successfully developing resistance to the new forms.

Techniques developed for isolating spotted alfalfa aphid resistance were used successfully in selecting for pea aphid resistance and blue alfalfa aphid resistance. A number of alfalfa cultivars have been developed with resistance to both spotted alfalfa aphid and pea aphid (Table 2). Progress on development of blue alfalfa aphid resistance has also been rapid since this insect was reported in damaging numbers on alfalfa in California in 1975 (Lehman and Nielson, 1976). CUF-101 was released for blue alfalfa

TABLE 2.--Partial list of alfalfa cultivars with insect resistance

Insect	Cultivar
Alfalfa weevil	Arc [*] , Liberty [*] , Team [*] , Weevlchek
Pea aphid (PA)	Apex, Baker ^{**} , Dawson ^{**} , Kanza ^{**} , Mesilla ^{**} , Riley ^{**} , Washoe ^{**}
Spotted alfalfa aphid (SAA)	Cody, El-Unico, Heyden, Mesa-Sirsa, Moapa, Sonora, Zia
Blue alfalfa aphid (BAA)	CUF-101 ^{***}
Meadow spittlebug	Culver
Potato leafhopper	Agate, Cherokee, Ramsey, Riley, Valor, Weevlchek

* Resistant to PA.

** Resistant to PA and SAA.

*** Resistant to BAA, PA, and SAA.

aphid resistance in 1977 and also is resistant to the spotted alfalfa aphid and pea aphid (Nielson and Lehman, 1977).

Sources of high resistance to the alfalfa weevil and potato leafhopper have not been found, but differences in susceptibility occur among experimental and commercial cultivars (Sorensen, et al., 1972). The principal mechanism of resistance in alfalfa to both insects is tolerance to feeding injury, measured as tolerance to yellowing or stunting caused by nymphs and adults of the potato leafhopper, or defoliation by the larvae of the alfalfa weevil. Field selection for tolerance has been the principal technique used in development of present resistant cultivars, although a number of greenhouse or laboratory techniques have been developed for screening alfalfa germplasm for resistance to these two species (Newton and Barnes, 1965; Webster, et al., 1968; Campbell and Dudley, 1965; Barnes, et al., 1969; Shade, et al., 1975). Techniques used to screen germplasm for alfalfa weevil resistance have also been used to evaluate resistance to the Egyptian alfalfa weevil (Lehman, 1971). However, no cultivars have been developed and released with resistance to this insect.

Culver, which was released in 1959, is the only alfalfa cultivar bred specifically for resistance to the meadow spittlebug (Wilson and Davis, 1960). It is relatively nonpreferred, moderately antibiotic, and highly tolerant to this insect. As mentioned previously various germplasm sources have been evaluated for resistance to the alfalfa seed chalcid and Lygus species but resistant cultivars have not been developed. Similarly, a range of reaction has been observed among alfalfa clones to the alfalfa plant bug (Radcliffe and Barnes, 1970), and the alfalfa blotch leafminer (Murphy, 1976), but there has been very little progress made in the selection for resistant germplasm.

RESEARCH NEEDS IN ALFALFA INSECT RESISTANCE

I have grouped the most important research needs in improving insect resistance in alfalfa in three categories as follows:

1. Improving levels of resistance to major alfalfa insect pests for which resistant cultivars are presently available. Probably the greatest need is for improved resistance to the alfalfa weevil, Egyptian alfalfa weevil, and potato leafhopper, but further research is needed in this area on the blue alfalfa aphid and meadow spittlebug. High levels of resistance to the alfalfa weevil have been reported in annual Medicago species (Barnes and Ratcliffe, 1969; Shade, et al., 1975) and some research effort is presently being directed to incorporating this resistance into M. sativa. Research to select for sources of antibiosis and/or nonpreference to the potato leafhopper is being conducted at Beltsville, Maryland and Manhattan, Kansas.
2. Developing resistant alfalfa cultivars to major insect pests for which resistant germplasm has been identified. The most important insects include the alfalfa seed chalcid and Lygus species which reduce seed production. Techniques for selecting for resistance have been developed and some possible sources of resistance have been identified,

but a more intensive effort will be required to develop resistant cultivars.

3. Developing programs to select for resistance to insects which presently are considered of less economic importance or of limited geographic importance. Insects included in the group would be the clover root curculio, alfalfa blotch leafminer, alfalfa snout beetle, stink bugs, etc. Limited research to develop selection techniques and isolate resistant germplasm has been conducted on the clover root curculio (Baker and Byers, 1977; Pesho, 1975) and alfalfa blotch leafminer (Murphy, 1976; Hill and Byers, 1979), but generally speaking this group of insects has received very little attention in plant resistance programs. Many reasons, such as the relative importance of the pest to alfalfa production, ease in rearing and handling the insect, other research priorities, etc. enter into the decision to develop a plant resistance program. However, as production costs increase and pest management programs receive greater emphasis in alfalfa production, the value of cultivars with multiple insect resistance will also increase, and development of resistance to many of the so-called minor pests will take on greater importance.

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SOILBORNE DISEASES OF ANNUAL CLOVERS IN THE SOUTH AND

METHODS OF SCREENING FOR RESISTANCE

By Robert G. Pratt

Annual clover species are utilized as legume components of warm- and cool-season pasture crops throughout the southern United States. Clovers are grown to increase the productivity of pastures by providing longer grazing seasons and more nutritious forages than are obtained with most grasses alone. They also enhance soil fertility by fixing nitrogen, thereby allowing continued production of grasses in mixed stands without applications of nitrogen fertilizer.

In spite of the importance of annual clovers to agriculture in the South, little research has been reported on soilborne diseases of these crops. Identities of diseases and loss estimates can only be inferred from empirical observations of scientists and growers and from research published on clover diseases in other areas of the U.S. and the world. Nevertheless, it appears likely that large and serious losses to soilborne diseases are experienced in clovers annually throughout the South and that the range, quality and productivity of these crops could be dramatically increased through programs of breeding for disease resistance.

Numerous examples are known of the failure, or dying out, of established stands of crimson (*Trifolium incarnatum*), arrowleaf (*T. vesiculosum*), subterranean (*T. subterraneum*) and other clovers throughout the South. Few of these have been documented in the literature (21, 23, 24). Many failures of clover stands are known or presumed to be due to root and crown diseases, but identities of diseases and causal organisms have often not been clearly established (21, 23, 24). Most research published on soilborne diseases of clovers in the South has involved red clover (*T. pratense*) in Kentucky (14, 31) and West Virginia (12, 13, 18) and white clover (*T. repens*) in Alabama (1, 17).

Soilborne diseases of annual clovers have been a research component of the USDA clover improvement program at Mississippi State University since the spring of 1978. The goals of pathology research there are to identify soilborne diseases which attack annual clovers in Mississippi and elsewhere in the South, to determine their host ranges and importance, to devise screening techniques for evaluating host plant resistance, and ultimately to breed and release improved, disease-resistant annual clover varieties. To date, at least six different diseases, or categories of disease, have been observed to cause damage in experimental plots, seed production fields, and mixed pasture stands. These diseases, and the principal clovers upon which they have been observed are: (1) *Sclerotinia* crown and stem rot (arrowleaf, crimson, subterranean); (2) *Phytophthora* root rots (arrowleaf); (3) *Fusarium* wilt (crimson); (4) Root rots caused by *Fusarium* spp. and possibly other imperfect fungi (arrowleaf, crimson, subterranean); (5) Southern blight (arrowleaf, subterranean); and (6) *Rhizoctonia* and other crown and stem blights (arrowleaf, subterranean). These diseases may occur individually or in combinations. Observations, screening techniques, and results obtained for these diseases are summarized as follows:

- (1) *Sclerotinia* crown and stem rot (*Sclerotinia trifoliorum* Erikss.)

This disease attacks forage legumes throughout the world. Extensive

research has been reported from Europe on red, white, alsike (T. hybridum) and crimson clovers. In the U.S., the disease has primarily been studied on red and white clovers in Kentucky (14, 31) and Pennsylvania (20, 25) and on alfalfa in North Carolina (33). Little research has been conducted on this disease on annual clovers in the South. Screening techniques have been based on naturally occurring field epiphytotics (10, 20), induced field epiphytotics (20, 31), and mycelial and ascospore inoculations in the greenhouse (9, 10, 20, 33). Some resistance or tolerance has been reported in red and white clovers (2, 11, 20, 31, 32) and alfalfa (33).

At Mississippi State, Sclerotinia crown and stem rot is severe on crimson and arrowleaf clovers. Research is underway to develop field screening techniques by adding sclerotia to soil at known densities. Clover varieties can then be screened for resistance under field conditions with semi-controlled inoculum levels, so that potential resistance to both ascospore and mycelial infection may be expressed in a natural environment.

(2) Phytophthora root rots (Phytophthora megasperma Drechs. and P. erythro-septica Pethyb.)

Phytophthora root rot is known to be an important disease on alfalfa throughout the U.S., but it has not been clearly shown to cause disease in clover species in the field. One report described the isolation of P. megasperma from roots of subterranean clover in Mississippi, but no field disease situations were described (22). The organism caused damping-off of arrowleaf clover and alfalfa seedlings in the greenhouse.

In 1978, root rot diseases were observed on arrowleaf clover at two locations in Mississippi. Phytophthora megasperma, P. erythro-septica and P. parasitica Dastur were isolated. Pathogenicity and host reactions were evaluated on six to eight-week-old plants grown in soil infested by methods similar to those previously described for alfalfa (29). Phytophthora megasperma from arrowleaf clover was highly virulent on arrowleaf and moderately virulent on crimson and subterranean clovers, but only slightly virulent on alfalfa. Several composited isolates from alfalfa also caused little damage on clover species. Phytophthora erythro-septica was highly virulent on crimson clover and less virulent on arrowleaf. Phytophthora parasitica was only slightly virulent to all clover species. Mass-screening experiments to locate resistance to P. megasperma in arrowleaf clover, using previously described techniques (29, 30), are in progress.

Phytophthora root rot diseases appear to be some of the major causes for failure of stands of arrowleaf, crimson, and possibly subterranean clovers in the southern U.S.

(3) Fusarium wilt of crimson clover (Fusarium oxysporum Schlecht.)

Numerous reports have described isolations of F. oxysporum from diseased clover roots (e.g. 16, 26), and in some instances isolates have caused root rot and dieback. However, classical Fusarium wilt symptoms (discolored vascular cylinders in roots; stunted, chlorotic tops; death of plants), as occur in alfalfa (15) and many other crops (6), have apparently not been reported from clover species grown in the field. One report does indicate that these may be produced when isolates from other host plants are inoculated onto clover (5).

In 1978, crimson clover plants with symptoms of red-orange discoloration in vascular cylinders of taproots and stunted, chlorotic, and wilted stems

and foliage were observed in a seed production field in which frost heaving of soil during winter had created root wounds. Fusarium oxysporum was consistently isolated from diseased root tissues. Symptoms similar to those observed in the field were obtained at Mississippi State when roots of plants grown in a growth room were immersed in suspensions of microconidia and transplanted. The organism was consistently reisolated from symptomatic root tissues. Only slight symptoms developed in arrowleaf and red clover plants inoculated in the same manner.

Techniques for inoculating plants with F. oxysporum to screen for resistance to wilt are well known (6, 15) and relatively easy to apply. However, breeding for resistance may be complicated because distinct pathogenic races of the causal organism are known on many crops (6).

(4) Fusarium and other root rots (Fusarium spp. + other imperfect fungi)

Fusarium spp. and other imperfect fungi have often been isolated from diseased clover roots. These may cause root dieback in inoculated plants and are considered as primary components of a root disease complex (27). However, root decay in red and alsike clovers is strongly influenced by environmental factors (19, 27) and may be partly caused by an internal physiological breakdown (19).

Fusarium solani, cultivars of F. roseum, F. moniliforme, other unidentified Fusarium spp., other imperfect fungi, and Pythium spp. have been isolated from lesions and rotted roots of arrowleaf, subterranean and crimson clovers at Mississippi State. Top symptoms (stunting and reddening of leaves and stems) associated with root damage were most distinct in early spring when plants commenced rapid growth. Pathogenicity trials with root isolates have not yet been attempted; thus, it is not known whether susceptibility and disease severity are sufficient to warrant screening for resistance in annual clovers. Similar diseases of subterranean clover in Australia are reported to be caused by an array of pathogenic fungi (7, 8).

(5) Southern blight (Sclerotium rolfsii Sacc.)

Several reports have described Southern blight attacking white clover in the South (3, 4). This is a warm-temperature disease and is probably more severe on red and white clovers than on earlier-maturing annual species. However, Southern blight killed many space-planted arrowleaf clover plants at Mississippi State in June, 1978. The disease is recognized by a white mycelium with small, light- to dark-brown sclerotia, which forms in crowns of infected plants. Attempts to screen for resistance in clover have apparently not been reported. Infection is easily obtained on other hosts by growing plants in soil amended with infested grain or other natural substrates.

(6) Rhizoctonia and other crown and stem blights (Rhizoctonia solani Kuhn, Rhizoctonia spp., other fungi)

Rhizoctonia solani and other Rhizoctonia spp. have been reported to cause root rot, stunting and crown blights of annual and perennial clovers (4, 18, 28). Inoculation techniques have also been described in these reports. Symptoms suggestive of a Rhizoctonia crown and stem blight disease were observed on subterranean clover at Mississippi State in 1978. This appeared similar to the

"barepatch" disease described on that species in Australia (28), but the identity of the causal organism was not verified.

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RECENT PROGRESS OF REGIONAL RESEARCH PROJECT S-127

ON FORAGE LEGUME VIRUSES

By M. R. McLaughlin

The S-127 project is a five-year research program begun October 1, 1977. The principal emphasis of the project is to acquire new information concerning the virus diseases of the major forage legumes grown in the Southeast. Another area of emphasis is the identification of sources of virus resistance within available germplasm and incorporation of this resistance into usable varieties. Concurrent studies of epidemiological factors important to disease development are also being conducted. The goal of the total research effort is the improvement of forage legumes through incorporation of virus-resistant varieties within a cultural framework of practical pest management practices and ultimately increasing the contribution of forage legumes to agriculture.

The objectives of the S-127 project are:

1. To identify, characterize and determine the distribution of viruses infecting forage legumes in the Southeast.
2. To evaluate the importance of these viruses relative to productivity, quality and persistence of forage legumes.
3. To establish the importance of selected factors in the epidemiology of virus diseases of forage legumes.
4. To reduce disease losses through pest management and plant breeding practices.

Research cooperators in the S-127 project (Table 1) represent the broad disciplines of agronomy and plant pathology within the research branches of the United States Department of Agriculture and various state agricultural experiment stations. Several cooperators are specialists in plant breeding while others are specialists in plant virology. Ten southeastern states and Arizona are currently represented in the project.

Research interests and specific projects of individual cooperators are many and varied and may not properly or adequately be covered in the context of this report. There are, however, some outstanding examples within S-127 of progress made through truly cooperative research. The remainder of this report is devoted to summary coverage of these exemplary research efforts.

VIRUS DETECTION AND IDENTIFICATION

Viruses infecting forage legumes cannot always be detected by symptom examination and even when symptoms are evident, it usually is not possible to identify the causal virus based on symptom expression alone. Observing

Table 1. Research cooperators in regional research project S-127.

ALABAMA

E. M. Clark
W. C. Johnson

ARIZONA

M. R. Nelson

FLORIDA

C. E. Dean

GEORGIA

J. W. Demski
M. A. Khan
* J. D. Miller
* H. D. Wells

KENTUCKY

S. Diachun
T. P. Pirone
S. J. Sheen

LOUISIANA

K. S. Derrick
B. G. Harville

MARYLAND

* J. P. Meiners

MISSISSIPPI

* W. E. Knight¹
* R. G. Pratt

NORTH CAROLINA

* W. A. Cope⁴
L. T. Lucas
* R. W. Welty

SOUTH CAROLINA

O. W. Barnett²
* P. B. Gibson
M. R. McLaughlin

VIRGINIA

S. Boatman
S. A. Tolin³

¹Chairman
²Past Chairman
³Vice Chairman
⁴Secretary

* USDA/SEA/AR

symptom expression of inoculated indicator host plants provides a good method of detection and identification for most of the viruses involved (1, 4, 6, 9, 13), but may not readily separate closely related viruses such as bean yellow mosaic virus (BYMV) and clover yellow vein virus (CYVV). The expense and time involved with growing indicator host plants and waiting for symptom development prompted efforts by S-127 cooperators to develop simpler and faster methods of virus detection and identification. To this end several serological procedures have been used successfully.

Immunodiffusion tests have been used to identify and determine strain relationships of the icosahedral viruses, peanut stunt (PSV) and cucumber mosaic (CMV) (15). Immunodiffusion tests using sodium dodecyl sulfate (SDS) have also been useful in identification and determination of strain relationships among the long flexuous rod-shaped viruses, BYMV, CYVV, clover yellow mosaic (CYMV), and white clover mosaic (WCMV) (8, 16). Latex agglutination tests which are quite sensitive and can be completed in 10-15 minutes have also been used to identify BYMV, CYMV, CYVV, WCMV and red clover vein mosaic virus (RCVMV) (1, 3, Khan & Demski, unpubl.). Serology has also been used in conjunction with transmission electron microscopy in detecting and identifying CYVV and PSV (7) and in identification of pea streak virus (14). The relatively new serological procedure, enzyme-linked immunosorbent assay (ELISA), has also been used to detect and identify BYMV, CYMV, CYVV, RCVMV, PSV, WCMV and alfalfa mosaic virus (AMV) (10, 11). The ELISA procedure was readily adapted to the virus indexing programs of S-127 cooperators. Antibody-sensitized ELISA plates were mailed by cooperators in South Carolina to cooperators in Alabama, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, and Virginia. Cooperators exposed the plates to sap preparations from various forage legumes, then returned the plates to South Carolina for completion of the ELISA procedure (12). From June through September, 1978, 1,034 forage legume samples were indexed for from one to seven viruses, representing a total of 5,734 individual tests and resulting in detection of 426 virus infections.

VIRUS OCCURRENCE AND DISTRIBUTION

During 1978, cooperators monitored replicated field plantings of alfalfa, Medicago sativa L.; alsike clover, Trifolium hybridum L.; arrowleaf clover, T. vesiculosum Savi; crimson clover, T. incarnatum L.; subterranean clover, T. Subterranean L.; red clover, T. pratense L. and white clover, T. repens L. Ten to 20 plants from common seed sources of each species were established at Tallassee, Alabama; Griffin and Tifton, Georgia; Lexington and Springfield, Kentucky; Beltsville, Maryland; Starkville, Mississippi; Raleigh, North Carolina; Clemson, South Carolina; Blacksburg, Virginia; and Baton Rouge, Louisiana. Plants were indexed from one to four times during the growing season for AMV, BYMV, CYMV, CYVV, PSV, RCVMV and WCMV. Indexing was done using indicator host plants, enzyme-linked immunosorbent assay and/or other serological procedures. The most prevalent viruses detected were BYMV, CYVV, and PSV, representing infection of 15%, 11% and 10%, respectively, of the 894 plants sampled. Other viruses and the percent of plants infected were AMV 0.6%, CYMV 0.6%, RCVMV 0%, WCMV 1% and unidentified viruses 4%. Virus infections (expressed as the percentage of total virus infections) detected among the legume species were alfalfa 4%, alsike clover 31%, arrowleaf clover 9%, crimson clover 5%, red clover 12%, subterranean clover 11%, and white

clover 27%.

VIRUS INFECTION AFFECTS FORAGE YIELDS AND PERSISTENCE

Studies of the influence of virus infections on forage yields are in progress. In South Carolina, the approach to this problem has been to monitor yields of inoculated plants grown within controlled environment chambers and within field chambers designed and operated to exclude insects yet expose test plants to field conditions. Results of these studies, a portion of which have been published (2, 5), indicate that single virus infections do indeed reduce forage yields. The greatest yield reductions were noted from plants which became infected early in the growing season. These studies have also shown increased mortality among virus-infected arrowleaf and white clovers, indicating the potential importance of virus diseases upon persistence of these clovers in the field.

IDENTIFYING VIRUS RESISTANCE

Work at several locations is underway to identify sources of virus resistance and combine it with agronomically desirable traits into usable lines. Recurrent selection combined with mechanical and aphid inoculations and field exposure of test plants has been used successfully by Cope (3), and Gibson and Barnett (4) in identifying sources of virus resistance in white clover.

In a regional test conducted in 1978, 100 promising white clover clones were selected from the breeding programs (established prior to cooperation in S-127) of Miller (Blacksburg, VA), Gibson (Clemson, SC), and Cope (Raleigh, NC). Two plants of each clone were grown in the field at each of the three locations. Plants were indexed late in the season for virus infection by the ELISA procedure and inoculation of indicator host plants. Progress in selection for virus resistance is indicated by the fact that as of September, 1978, all plants of 15 clones remained free of PSV at all locations.

SUMMARY

Progress in regional project S-127 has been realized in the areas of virus detection and identification, virus occurrence and distribution, effects of virus infection on forage yield and persistence, and in the identification of sources of virus resistance. The contributions of individual cooperators, significant in their own right, have achieved even greater impact through the cooperative effort being put forth in S-127. Cooperation between agronomists and plant pathologists, between USDA/SEA/AR and state agricultural experiment station personnel, and among researchers in eleven states, has been and will remain the key to continuing progress in S-127.

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RAPID DETERMINATION OF FORAGE QUALITY WITH A NEAR INFRARED FILTER SPECTROMETER

By Donald Burdick, F. E. Barton II, and Billy D. Nelson

Agronomists, animal nutritionists, feed manufacturers, and others involved in the production and manufacture of feeds, and the feeding of livestock have long sought a simple method for rapidly and accurately determining the quality of feeds.

In the last few years near infrared reflectance (NIR) spectroscopy has been investigated as a means of accomplishing this (1,2,3,5). Briefly, the near infrared region includes that part of the electromagnetic spectrum from about 0.6-2.5 μm . Although measurements in the mid infrared region (2.5-15.0 μm) commonly have been used to provide information on the structure of various organic substances, until recently, little attention had been placed on quantitative measurements in the near infrared region. Reasons for this are that almost all organic constituents have multiple absorptions in the near infrared (e.g. protein absorbs at more than 20 wavelengths) and often more than one constituent absorbs at the same wavelength. Also, compared to the basic infrared region most organic substances have very low molar absorptivities in the near infrared region. The results of this was much mutual interference and confusion. However, due to recent advances in near infrared instrumentation including improved NIR spectrum generation and low-level light detection circuitry, together with availability of low-cost computers to control instrument operation and analyze data, many of these limitations have been appreciably reduced or eliminated (4).

Presently, several companies are manufacturing NIR instruments suitable for forage investigations. These include Dickey-John, Digilab, Lamont, Neotec, Nicolet and Technicon.

Both the Neotec model FQA 51 Feed Quality Analyzer and the Neotec Spectrocomputer have been used in our studies.

The FQA 51 contains six tilting filters and covers selected regions of the NIR from 1.5-2.4 μm . The unit contains an Intel Model 8080 Micro-computer to control functions, perform multiple regressions, calculate standard errors, and present data. Two "Versi Dump" programs print out each filter's optical data applied to one of two maths.

1) Versi Dump 1 prints optical density (OD) data, $\log(1/R)$ in 120 data points.

2) Versi Dump 2 prints second derivative data ($d^2(\log 1/R)d\lambda$) in 60 data points.

The data obtained from these printouts can be plotted and regression analysis run to determine new wavelengths of maximum/minimum absorbance (reflectance) with the lowest standard errors for new products. As received our FQA 51 contained filters of the following wavelengths (μm): (#1) 1.596-1.677 (Ref), (#2) 1.501-1.577 (urea), (#3) 1.842-1.936 (moisture), (#4) 2.108-2.216 (protein), (#5) 2.243-2.308 (fiber), and (#6) 2.263-2.328 (oil). The instrument

was precalibrated at the factory to predict protein, fat and fiber for four feed categories which included mixed poultry and swine rations, and dairy and beef rations with and without urea. The instrument was not calibrated nor were filters supplied to specifically predict forage parameters relating to forage quality.

In our laboratory we are primarily concerned with the application of NIR for predicting the quality of tropical or warm-season forages which are grown in the South. From results of our chemical and ultrastructural investigations we know that warm- and cool-season grasses differ in tissue types, chemical composition, and digestibility. Accordingly, we thought that these two groups of grasses may absorb differently in the NIR.

Initially, we ran 24 forage samples consisting of ten warm-season grasses and 14 cool-season species as two separate groups and together as one group. From the results it was apparent that lower standard errors were obtained when the warm- and cool-season forages were evaluated in separate groups. Also, that the FQA was not optimized to predict forage composition and digestibility with the same accuracy as the empirical analytical methods. Our initial objective, therefore, was to determine the optimum wavelengths which relate to forage quality parameters and to apply these to the FQA 51. We first accomplished this using the Versi-Dump 2 program. The second derivative data obtained were manually plotted to determine new wavelengths of maximum/minimum absorbance (reflectance) for each filter which relate to specific forage constituents. As originally programmed filter #1 (1.596-1.677 μm) was used as a reference and data generated by it were divided into data from the other filters to reduce noise. Neotec found that this had improved protein measurements on mixed feeds and oilseed meals due to little or no absorbance occurring in the range of this filter for these products. However, using the Versi-Dump 2 program we found that appreciable absorbance occurred at 1.667 μm for tropical grasses compared to temperate species. For tropical grasses primary absorbance bands for ADF are shifted to higher energy and are found in this region. For temperate grasses Shenk *et al.* (6) have found 1.702 μm useful for predicting ADF. Lignin and NDF also were found to absorb in the range of this first filter. As tropical forages absorb NIR in the range of the reference filter subtracting these data from absorption data from the other filters produced spectra with numerous sharp peaks, unlike the usual smooth broad peaks. Therefore, this division term was eliminated from the program.

Although the Versi-Dump program is useful, manually plotting the voluminous data which are generated, and visually examining and selecting new data points (wavelengths), is tedious and time consuming. Also, as gaps (dark areas) exist between each filter less than one-half the entire NIR region (i.e. 720 of 2000 data points) is actually covered! We therefore resorted to use of the Neotec Spectrocomputer. This instrument is equipped with a Cary 14 monochromator and Data General Nova 2 Computer. With the monochromator the entire NIR region can be scanned and a hard copy plot of the spectrum obtained. The computer associated with this instrument also computes a multiple regression equation and standard error for each forage component. The program also permits deletion of the worst 1-2 samples, and recomputation of the regression equation and standard errors so that the magnitude of the improvement obtained can be evaluated. The correlation of specific wavelengths with forage constituents is also given.

Our objective was to use the Spectrocomputer to select wavelengths which correlate best with those forage parameters (e.g. crude protein (CP), acid

detergent fiber (ADF), neutral detergent fiber (NDF), permanganate lignin (PML), and *in vitro* dry matter disappearance (IVDMD)) which prescribe forage quality. These wavelengths were then applied to the FQA 51 for further evaluation and routine analysis of forages.

A disadvantage of the Spectrocomputer is that the radiation transmitted by the monochromator and associated optics is considerably less (50%) than that of the filter-type instrument. Also, where the FQA 51 takes 720 data points over the 1.5-2.4 μm region the Spectrocomputer only takes 300 data points. As we wished to compare results from the two instruments on as similar a basis as possible, the NIR region of the Spectrocomputer was divided into two segments (1.5-1.95 μm and 1.95 to 2.4 μm) and the 300 data points were assigned to each of these regions. Thus, it was necessary to make two scans with the Spectrocomputer to cover the entire NIR region. Also, 10 and 12 data points were used to calculate each second derivative term for the FQA and Spectrocomputer, respectively.

For this work 39 freeze-dried bermudagrass samples consisting of 4- and 8-week-old cuttings of several different cultivars (e.g. common, Coastal bermudagrass, Coastcross-1, Callie, Alecia, Tifton 44) were selected to give a representative range in chemical composition and digestibility and divided into two sets, 28 for calibration and 11 for prediction.

Primary and secondary wavelengths of maximum correlation were selected by the Spectrocomputer with the calibration set for the two NIR ranges. These wavelengths were then transposed to the FQA 51. The 1.68 μm filter (Filter #1) was replaced with a 1.72 μm filter. This was done because of the high correlation of ADF at 1.707 μm determined with the Spectrocomputer. Next, the Versi-Dump program was employed to obtain a plot of the absorbance (reflectance) data when the wavelengths were slightly shifted about the λ max. Examination of the spectra revealed that perhaps certain additional wavelengths also should be evaluated to achieve the best regression and lowest standard error. Additional wavelengths were therefore selected; however, due to the instrument having only six filters and the requirement to use data from much of the filter to calculate the second derivative only one wavelength (data point) per filter could be used. Accordingly, additional product files had to be set up to accommodate the various combinations of wavelengths.

Since our initial studies the FQA 51 had been revised so that it now had the capability of performing step-wise, multiple regression analyses using up to six wavelengths per constituent. The calibration set of 28 bermudagrass samples was run and regression equations for predicting forage constituents were obtained. Data in Table 1 show the wavelength(s) finally selected for the multiple regression equation which resulted in the lowest standard error for predicting the composition and digestibility of the 11 bermudagrass samples. Standard errors of prediction for the FQA 51 compared to analytical values are shown in Table 2. Laboratory data and predicted values for Coastal and Coastcross-1 bermudagrass also are shown in Table 3.

In our research on forage quality we have been cooperating with the Coastal Bermudagrass Processors' Assn. in Estill, S.C. This industry produces a dehydrated, pelleted product which is primarily used as a carotene-xanthophyll source in poultry feeds. We receive samples of pellets from one cooperator on a regular basis together with a copy of crude protein and carotene values which he obtains from a commercial analytical laboratory. We had about 30 of these samples on hand at the time and decided to see how well the predicted protein values obtained by NIR compared to the commercial laboratory values.

TABLE 1.--Wavelengths selected for predicting forage constituents relating to quality

Constituent	λ 's
Crude protein	2.183
Acid detergent fiber	1.691, 2.338
Neutral detergent fiber	2.097
Permanganate lignin	1.678, 2.117, 2.298
<u>In vitro</u> dry matter disappearance	1.714, 2.097, 2.187

TABLE 2.--Standard errors of prediction of bermudagrass^{1/} composition with NIR^{2/} compared to analytical methods

Standard Errors		
Constituent	NIR	Lab
Crude protein	0.58	0.5
Acid detergent fiber	1.07	1.0
Neutral detergent fiber	2.77	0.8
Permanganate lignin	0.66	0.5
<u>In vitro</u> dry matter disappearance	1.90	2.7

^{1/}11 freeze-dried bermudagrass forages

^{2/}Neotec FQA-51

As the second derivative curve for the dehydrated, pelleted bermudagrass samples was similar to the curve for the 28 freeze-dried bermudagrass samples we thought the same calibration also may be valid for this group of samples. In considering this new sample set the following possibilities existed:

1. The regression equation developed for the 28 freeze-dried bermudagrasses also is valid!
2. The wavelengths are valid, but recalibration is necessary!
3. The wavelengths are not valid; therefore, new data points have to be selected and the instrument recalibrated.

TABLE 3.--Standard errors of calibration and prediction (NIR) compared to analytical values for bermudagrass hays^{1,2/}

Constituent	Cal.	Pred.	Lab
Crude protein	1.15	0.84	0.5
Acid detergent fiber	2.46	1.42	0.8
Neutral detergent fiber	2.06	1.39	1.0
Digestible dry matter ^{3/}	1.78	2.54	3.1

^{1/}FQA-51

^{2/}Common and Coastal bermudagrass hays, Louisiana, oven dried. Cal.=20 samples, Pred.=22 samples.

^{3/}In vivo

TABLE 4.--Comparison of predicted values (NIR) and laboratory values for selected bermudagrasses

	Coastal bermudagrass		Coastcross-1 bermudagrass	
	<u>NIR</u> %	<u>Lab</u> %	<u>NIR</u> %	<u>Lab</u> %
Crude protein	9.9	9.8	17.0	17.1
Neutral detergent fiber	65.0	64.9	58.1	53.9
Acid detergent fiber	35.9	34.9	28.4	28.3
Permanganate lignin	3.7	3.8	3.2	2.9
<u>In vitro</u> dry matter disappearance	58.0	58.6	68.2	70.3

Using the same regression equation and calibration, protein values were obtained which were about 30-50% lower than the laboratory values. For example, instead of a value of 15% crude protein, we obtained a value of only 10%. We therefore recalibrated using 20 of the 30 dehydrated samples. New wavelengths were selected from the same set of six filters. The remaining 10 samples were used as unknowns for prediction. Upon doing this, we obtained standard errors of calibration and prediction for crude protein of ± 0.78 and $\pm 0.72\%$, respectively. We therefore concluded that the wavelengths were valid. Supporting this conclusion was the fact that by using the Versi-Dump program no further improvement in the standard error of prediction was obtained.

We also predicted the quality of 42 oven-dried samples of common and Coastal bermudagrass hays with the same set of filters and wavelengths used

for the 28 freeze-dried bermudagrass samples. In this case, the calibration set consisted of 20 samples and the prediction set, 22 samples. Standard errors of calibration and prediction for CP, ADF, NDF and dry matter digestibility (*in vivo*) compared to analytical data are shown in Table 4. From these data it appears that good agreement between the analytical values and NIR predicted values was obtained.

CONCLUSION

Near infrared reflectance spectroscopy is a useful tool for rapidly predicting forage quality. However, to ensure that reliable data are obtained it is imperative that the instrument's calibration be checked, and perhaps even new wavelengths (filters) selected, when evaluating different forage species, various groups of forages, or forage products which are produced in different ways such as field-cured hay or mechanically dehydrated pellets.

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ALFALFA FOR THE SOUTHERN REGION--PROBLEMS AND PROMISES

INTRODUCTORY COMMENTS

By Warren C. Thompson

Alfalfa has been grown longer in the southern states than any other area in America (1). In fact, alfalfa was introduced to the American agricultural scene in 1736 in the state of Georgia, long before it was grown by George Washington and Thomas Jefferson around the 1790's. It was in 1850 before it was introduced on the West Coast. Then in 1857, it was introduced to the North Central States - in Minnesota by Wendelin Grimm. He was later to have the famous "Grimm" cultivar named for him.

The acreage of alfalfa has changed very little in the South Atlantic States since 1920. At that time, the acreage was estimated at 1.0 million acres, about the same as 1970. The records do indicate however that there was a real acreage bulge beginning in the late 1940's running through the early 1960's. But with the advent of the massive invasion of the alfalfa weevil, the 1965 acreage dropped back to the 1.0 million mark.

In recent years, since 1970, the acreage has turned upward again - to 1.24 million. Per acre yield has risen from an estimated 1.5 tons per acre to 1.7 in 1950 and to 3.15 in 1978 (table I).

TABLE I. Alfalfa Production South Atlantic States - 1978

State	Harvested acres	Yield (T/ac)	Total tons
Arkansas	68,000	2.90	197,000
Kentucky	208,000	3.10	645,000
Louisiana	13,000	2.05	27,000
Maryland	68,000	2.90	197,000
Mississippi	12,000	2.85	34,000
North Carolina	16,000	2.30	37,000
Oklahoma	400,000	3.30	1,320,000
Tennessee	100,000	2.45	245,000
Texas	180,000	4.70	846,000
Virginia	82,000	1.80	148,000
West Virginia	80,000	2.25	180,000
<u>Below are estimates</u>			
Florida	5,000	(est) 3.15	16,000
South Carolina	4,000	3.15	13,000
Georgia	5,000	3.15	16,000
Alabama	2,000	3.15	6,000
	1,243,000	(Av.) 3.15	3,927,000

The question is often asked, "Why aren't more acres of alfalfa grown in the South? Why is it that a state with such a harsh climate (Wisconsin) grows more than two times as much alfalfa as all of the 15 South Atlantic States combined?"

What are the potentials and needs we have for the future? Could it be plant materials, production systems, and educational programs designed for the southern farmer? It is not at all unusual to find data in these states that show yields of 7 to 10 tons even as high as 12 tons per acre. But in most cases that can be confirmed, these yields are attained at a research complex.

These questions and opportunities will be dealt with by this panel. How well farmers perform depends on how well we set our priorities and get the job done back home.

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6. Poor insect control -
 - A. Alfalfa weevil - Lower yields and some stand loss with present infestation levels.
 - B. Potato leafhopper - Lower yields and some stand loss with infrequent economic infestations.
 - C. Aphids - Lower yields and some stand loss, mainly on first cutting.

7. Poor fertilization and liming practices - Lower yields and loss of stands.

8. Poor harvest methods -
 - A. Late cutting - Poor quality hay.
 - B. Raking and baling too dry - Loss of leaves, poor quality hay.
 - C. Weather damage - Loss of leaves, leaching of nutrients.

ALFALFA FOR THE SOUTHERN REGION--PROBLEMS AND PROMISES

PLANT BREEDING PROGRESS ON SOLVING ALFALFA PROBLEMS IN THE DEEP SOUTH

By E. S. Horner

The Florida alfalfa breeding project was started in 1950 with the objective of developing a variety with improved yield and longevity of stands. Varieties available at that time did not persist well enough in Florida to produce satisfactory yields in the second year. About 70 plant introductions and 30 U.S. varieties were planted in small plots, and open-pollinated seed were harvested from the most vigorous accessions in 1951. These were bulked and used as the source population for a mass selection program. The first three cycles of selection each consisted of establishing space-planted nurseries of about 2,000 plants and harvesting open-pollinated seed from 50 or more of the most vigorous surviving plants 2 years after planting. Beginning with the fourth cycle the seed were drilled in rows in blocks up to 0.5 hectare in size, and stands were maintained for 3 years before the seed were harvested with a combine from surviving plants to initiate a new cycle. Ten cycles of selection have now been completed. Additional plant introductions and germplasm releases have been evaluated at various times since 1950, and seed from selected plants have been added to the breeding population to further broaden the genetic base.

Sufficient improvement in persistence of stands was obtained by the end of six cycles of selection to enable us to release 'Florida 66' in 1969. This variety in several tests was equal or superior to commonly used varieties such as 'Hairy Peruvian' and 'African' for yield in the first harvest season, and was markedly superior to these varieties in subsequent harvest seasons because of better stands. Commercial seed of Fla. 66 was produced in California in 1970, but the seed company involved changed hands and the new owners decided to use the land for other crops. Our foundation seed stocks organization was not able to interest other seed producers in this variety because it is susceptible to the spotted alfalfa aphid.

Since we were not equipped to screen for spotted alfalfa aphid resistance in Florida, we contacted Dr. M. W. Nielson, USDA Research Entomologist at Tucson, Arizona. Dr. Nielson screened our breeding population for resistance to Biotype H, and found that about 0.8% of the plants were resistant. He returned 180 resistant seedlings which were intercrossed; the intercrossed seed were returned to him for the second cycle of selection, and about 600 resistant plants were obtained. These plants were intercrossed to produce a spotted aphid-resistant population (temporarily called Florida 66A), which has been tested at Gainesville in two experiments. In one test (established by Dr. O.C. Ruelke in 1976), estimated stand percentages in the spring of 1979 were 81 and 66 for Fla. 66A and Fla. 66, respectively. None of the commercial varieties in the test had better than a 50% stand, and most had stands ranging from 10 to 30%. These losses in stand were due partly to severe drought stress in both 1977 and 1978. Forage yield of Fla. 66A was equal to the best commercial varieties in the first and second harvest years and should be much better the third year because of superior stands. A separate test planted a year later

has given similar results. The new variety appears to be an improvement over Fla. 66 in both yield and persistence.

Our results show that it has been possible to greatly improve stand persistence of alfalfa in Florida by the mass selection technique described above. At the same time yields have been maintained at a very satisfactory level. The variety we are now increasing in California, Fla. 66A, should perform well in the southeastern coastal plain area.

ALFALFA FOR THE SOUTHERN REGION--PROBLEMS AND PROMISES

ALFALFA BREEDING PROBLEMS AND SOLUTIONS FOR ALABAMA

By R. L. Haaland, C. S. Hoveland, Fred Gray,
Ed Clark, and R. Rodriguez-Kabana

Poor stand persistence and sorry seed supply are the two major problems limiting alfalfa production in Alabama as well as the rest of the southeast.

PERSISTENCE

The biggest agronomic problem is persistence. Although it appears to be only one problem to a producer, it is a very complex problem to an alfalfa breeder. We have been trying to get a handle on this problem in Alabama for four years.

Visual Symptoms

Alfalfa stands that are deteriorating show several characteristic symptoms. The crown weakens and growth buds are destroyed. The crown eventually becomes completely rotten and individual plants turn chlorotic and die. When a weakened plant is dug, the root system is usually intact; however, the rotting and discoloration usually progresses from the crown down into the main tap root.

Causal Organisms

We have isolated many different genera and species of pathogens from deteriorating alfalfa stands; however, the primary causal organism(s) of the stand atrophy is (are) not known. The pathogens isolated in Alabama (Table) include fungi, nematodes, and insects. We have not found bacterial wilt to date.

Breeding Objectives

Our main objective in Alabama is to develop cultivars with a broad genetic base that exhibit multiple pest resistance. We have evaluated several thousand plants representing over one hundred different germplasm sources. After a four year period of harsh treatment (clipping 6 to 7 times per year at ground level), approximately 100 plants with non-dormant to semi-dormant characteristics were selected based on excellent vigor to constitute a broad base synthetic. This will be the basis of the first Auburn cultivar and be parental material for further selection work. What makes the selected plants superior? We don't know the specifics but we do know these plants survived heavy infestations of many of the organisms listed in the Table.

More detailed work has been initiated to develop tolerance to several nematode species, rhizoctonia, and fusarium.

Other problems that may enhance stand atrophy include subsoil acidity and periodic droughts. Acid tolerance may be beneficial and a stronger root system with nematode tolerance would be helpful under drought stress.

SORRY SEED SUPPLY

I'm sure this topic will be discussed thoroughly by other speakers but there are some points that agronomists in the "Deep South" should address themselves to. Seed production has been a minor side-line to other farm activities. The usual procedure is to scatter seed on the field and harvest seed if the farmer gets around to it. If not, either cut it for hay or bush-hog it down as it's time to spray the cotton.

What if we adapt seed production cultural techniques used elsewhere to the Southeast? Plant the alfalfa in rows, apply herbicides, cultivate, add bee attractants and bees, defoliate and harvest seed well ahead of the Western harvest. The so-called "dependability" of Western seed production leaves much to be desired. Even if we get half of the per acre seed production of the far West, seed transportation costs are reduced, and seed is available sooner to Southern livestock producers.

The seed production challenge will not be without problems, but a challenge without problems is no challenge at all.

CONCLUSION

The future of alfalfa in the "Deep South" is bright and will be brighter. Alfalfa will fit into several of our existing and to-be-developed livestock systems. New multiple pest tolerant cultivars, a dependable seed supply and some aggressive promotion are the keys to success.

TABLE.--Pathogens found on alfalfa in Alabama

Fungi	Nematodes
Cylindrocladium sp.	Dagger
Fusarium graminearum	Lance
F. lateritium	Leison
F. moniliforme	Ring
F. oxysporum	Root knot
F. semitectum	Spiral
F. solani	Stubby root
Phythium sp.	Stunt
Phytophthora megasperma	
Rhizoctonia solani	
Sclerotinia trifoliorum	
Sclerotinum rolfsii	
	Insects
	Alfalfa Weevil
	Three Cornered Alfalfa Hopper

ALFALFA FOR THE SOUTHERN REGION--PROBLEMS AND PROMISES

ALFALFA PROBLEMS AND POTENTIAL SOLUTIONS FOR GEORGIA

By J. H. Bouton

In Georgia, interest in alfalfa has historically been cyclic. This trend is found beginning with a series of bulletins by Fain and Vanatter (5) and McClelland (7) which documented the crops' potential as early as 1914. Interest increased again during the 1950's with production of alfalfa reaching a high in Georgia of 31,940 acres in 1960. There is renewed interest with 5,135 acres planted today after a low of 1,163 acres during 1970.¹ Even this Southern Pasture and Forage Crop Improvement Conference has been in the cycle. As we participate in this panel discussion, it is ironic to see in the proceedings of the sixth meeting in 1949 at Raleigh a symposium entitled "Place of Alfalfa in the Southeast." At this symposium the Georgia researchers reported the increased popularity of alfalfa and gave a guarded report of research being conducted in soil fertility to increase yield and persistence (8).

The biological problem is still lack of persistence of alfalfa in Georgia (1). This term persistence is all inclusive and would mean thin stands resulting from diseases, insects (predominately the alfalfa weevil in Georgia), non-adaptive varieties, poor soil conditions, and/or improper harvesting. Using adaptive varieties and keeping management at a high level insures dense, productive stands. But, one has only to look again at the early publications of 1914-1920 to find sound management recorded and available for Georgia (4,5,7). These publications can be summarized as follows: use a well-drained soil, add lime and fertilizer elements of phosphorus, potassium, and boron, choose a productive variety, inoculate seed with viable bacterial inoculum, plant in fall of year on a prepared seedbed, and harvest crop during early bloom. Later, it was added to spray for alfalfa weevil as this pest became a serious problem.

What is important from the above management sequence is the fact that it is sound (these same practices were basically followed when establishing and managing Georgia's variety trials this past year); but, most of all, that it is sixty years old. It is also important that Fain and Vanatter (5) reported yields in 1913-1914 of 5-6 tons per acre. Those same yields were obtained in Georgia during variety trials of the 1970's (6). So, why didn't Georgia's farmers go to alfalfa and stay with it?

Though the disease and insect problems are severe and make management difficult, one needs also to look at other reasons for the failure of alfalfa to assume a role as a major forage crop in Georgia. Prominent in the early decades of this century was the fact that cotton was an institution unto itself. In Georgia, cotton production reached 6 million acres in the 1930's. As interest in cotton declined, the number of Georgia dairy and beef producers grew. There was a concurrent increase in the use of perennial grasses. These grass systems were ideal to this growing livestock industry and today still form the

¹Agronomy Summary 1950-78. Compiled by J. E. Jackson, Georgia Cooperative Extension Service, University of Georgia, Athens.

base of forages in Georgia. But, they also created a problem for the legumes because even under poor management grasses are productive and persistent. When producers tried to manage alfalfa as they did the grasses, it resulted in poor stands and poor yields.

It is hoped the renewed interest in alfalfa the past few years is more real than in the past. With the high and increasing price of nitrogen fertilizer and the current price of grain and other feeds, Georgia's livestock and hay producers are giving this high yielding, protein rich, and nitrogen fixing legume another look.

The potential of the crop lies in agricultural research. In Georgia, a new research effort in plant breeding and management of alfalfa is being conducted. Since the yield and longevity of alfalfa has not changed much in 60 years then surely there is great potential to increase this through plant breeding and genetics. Broad-base genetic varieties selected under Georgia's conditions should offer better persistence. Plant breeding programs to develop new high yielding, disease and insect resistant germplasms will be needed. Of necessity, these breeding programs must be part of an overall forage program of management, utilization, soil fertility, pathology, nematology, and entomology.

Use of more alfalfa-grass mixtures is ideal for Georgia since perennial grasses such as tall fescue and bermuda make up the majority of forage acres in Georgia. It is felt that alfalfa has the potential to add quality and to increase production of these grasses especially during the time of the year when yield and quality of each respective grass is low (summer for fescue and spring or fall for bermuda). Research in Georgia is primarily aimed at this for direct grazing and includes management under these conditions as well as selection and breeding better grazing types.

Acid soils and its associated toxic metals such as aluminum and manganese are a problem in Georgia. Alfalfa is sensitive to acid soils as are the Rhizobium meliloti which nodulate it. However, the ability to tolerate acid soil was shown to be a heritable trait in alfalfa (2). Differences among strains of R. meliloti to survive and nodulate better in acid soils have also been reported (8). Research is now underway to recurrently select both alfalfa and R. meliloti as part of a genetic study. As the ability to root deeper into acid subsoils might lead to more persistence in alfalfa, it is hoped that this plant breeding approach will be important.

From the above discussion, it is noted that knowledge has always been available for growing alfalfa in Georgia. However, beef, dairy, and hay producers ultimately decide which forages they will use. The cycles since the early years of this century have shown they wanted to grow alfalfa, but problems and circumstances prevented this. Acreage of alfalfa will increase if the research, varieties, and extension keep pace; but, most of all, if the producer is convinced he wants it in his forage program.

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ALFALFA FOR THE SOUTHERN REGION--PROBLEMS AND PROMISES

PANEL DISCUSSION: AN INDUSTRY VIEWPOINT

By Jim B. Moutray

Throughout the South today there is more interest in growing alfalfa than there has been in 20 years. It appears that acreage could rise substantially in the next few years. Certainly the newer varieties are yielding and persisting better than those we had ten to twenty years ago. However, no truer words were spoken at last year's conference than when Bill Cope said, "Legume breeders are faced with the very pressing problems of developing pest resistance." This is certainly true of alfalfa. Diseases are the most important reason we don't have more alfalfa in the South now. Insects and nematodes are also taking a toll.

DISEASES

1. Sclerotinia - A devastating problem - resistance hard to pinpoint.
2. Rhizoctonia - Little progress in developing resistant varieties.
3. Phytophthora - Resistant varieties available, better adapted ones needed - of 34 soil samples tested from the South, 82 percent had Phytophthora present.
4. Anthracnose - Severe in many areas.
5. Crown rot complex.

INSECTS

1. More weevil resistance or tolerance needed.
2. Other plant bugs.

NEMATODES

1. Many species of root feeders.
2. Stem nematode.

OTHER AREAS WHERE IMPROVEMENT IS NEEDED

1. Grazing types with low set crowns and creeping ability.
2. Branched root types.

3. Tolerance to low pH conditions.
4. Better understanding and use of adapted rhizobia.
5. Farmer resistance through the use of harsh selection techniques.

THE SEED SUPPLY

All of the genetic improvements in the world will not help the producer if seed is not available. The alfalfa seed supply in the South right now is not good. There are reports of persistent producers driving hundreds of miles to obtain seed of improved varieties. The seed supply problem seems to be due to three factors.

1. Fall Seeding

In the most important alfalfa growing areas, spring seeding often takes priority in the seed supply chain.

2. Lack of Outlets

There are not enough seed houses selling alfalfa. I believe the situation has improved somewhat in the past two years, but much more improvement is needed.

3. Short Supply

Four out of the last five years, seed production in the West has been down. The main culprit has been weather. In California, Idaho, Washington, Oregon, and Nevada, where nearly 80 percent of the U.S. crop is produced, untimely rains at harvest have devastated the crop again and again. In 1978, western seed production acreage was up 24 percent compared to 1977; however, cool weather in August and rains in September resulted in 44 percent less seed. Low yields have resulted in seed prices in the \$2.50 - \$3 range, another factor in preventing the expansion of acreage in the South. Western seed producers who spend over \$600 to establish and grow an acre of alfalfa are still optimistic and have increased acreages in 1979. Hopefully, the supply will be better in the 1980s.

ALFALFA IN THE SOUTHERN REGION--PROBLEMS AND PROMISES

PANEL DISCUSSION: A FEDERAL RESEARCH PERSPECTIVE ON ALFALFA BREEDING IN THE SOUTHERN REGION

By J. H. Elgin, Jr.

Diseases, insects, nematodes, soil-related factors, harsh summer climate, poor seed supply, competition with other crops, lack of farmer familiarity, and, no doubt, several other reasons can be given for why alfalfa, "Queen of the Forages," is not grown extensively in the South. Whatever the reasons may be, one thing is evident: Developing alfalfa for the South has emerged as a major objective for both Federal and State research.

Four years ago, alfalfa breeding research in the Southern Region was limited to North Carolina, Arkansas, and Florida. Today, additional breeding research can be found in Virginia, Georgia, Alabama, and Oklahoma. Some breeders are working to improve their breeding lines for resistance to anthracnose, Fusarium wilt, potato leafhopper, alfalfa weevil, pea aphid, spotted alfalfa aphid, nematodes, and soil mineral toxicities. Others, not knowing the specific factors involved, are breeding for a general increase in persistence and productivity.

With the new emphasis on alfalfa research experienced in the last 4 years, the opportunity now exists to "zero in on" identifying the factors that limit alfalfa persistence and productivity in the South. Once these factors are identified, rapid development of new and improved cultivars should occur, and renewed interest in alfalfa among farm users should result. Let's not miss this opportunity. Southern breeders may not get a second chance.

In addition, because of the increased number of southern alfalfa breeders, opportunities to communicate and cooperate abound. By working together and evaluating one another's breeding lines and sharing information freely, southern breeders will produce highly productive persistent cultivars not only for their own States and local areas of interest but for the entire South.

So, the Federal perspective is clear. As in the rest of the United States, through research, alfalfa will someday become the No. 1 forage legume in the South. However, before that day comes, many breeding improvements need to be made. USDA cannot, nor should not, do it all. But, by working together--Federal, State, and Industry--the day of the "Queen" will come soon to the South.

BREEDING FOR DISEASE AND FREEZE RESISTANCE IN BLUE LUPINES

By Homer D. Wells

European bitter (high-alkaloids) land-races of blue lupine, Lupinus angustifolius, yellow lupine, L. luteus and white lupine, L. albus, became popular nitrogen-fixing cover crops in the southeastern United States during the 1930's and 1940's (1, 15). The winter temperatures were such in those years that European land-races of white lupine did well in Georgia from about Macon north to Griffin and Athens; blue lupine was very productive over the panhandle of Florida and north to Macon and Augusta, Georgia; and yellow lupine was very productive from Orlando, Florida, north to the vicinity of Tifton, Georgia. Immediately after World War II, the sweet (low-alkaloid) yellow lupine cultivars were introduced into Florida where they rapidly became popular as winter pasture. However, Bean Yellow Mosaic Virus (BYMV) which was seed-borne in yellow lupine soon eliminated this crop (1).

In November of 1951, a hard freeze destroyed most of the lupine plantings in the Southeast. Since that time, hard winters have made lupine production undependable with the European land-races and with other cultivars without increased winterhardiness (6). Dr. Ian Forbes, Plant Breeder, and I, Plant Pathologist, were assigned the task of improving blue lupines in 1953. Our objectives were: 1) take advantage of the low alkaloid sweet genetic stocks recently developed in Europe and give blue lupine the added dimension to serve as a forage and feed grain crop; 2) find and introduce disease resistance into our breeding lines; and 3) find and introduce the maximum available cold tolerance into our breeding lines.

Prior to Dr. Forbes' and my arrival on the scene, a seed company had released 'Simpson's Sweet Blue Lupine'. This release was either contaminated with bitter types or soon became contaminated in the seed trade to the extent that it was of no value as a forage crop. 'Borre' sweet blue, developed in Sweden and carrying the iucundus (iuc) gene for low alkaloid (sweetness) was evaluated, individual plants tested for sweetness, increased and released as a certified sweet cultivar in Georgia (3, 6). Since seed and flower colors and plant characters were identical with many of the common bitter types grown throughout the area, many seed lots soon became so contaminated with bitter types that the forage was rejected by livestock. Therefore, Dr. Forbes introduced the pleiotropic marker gene leucospermus (leuc) and combined it with the iuc gene and released the new cultivar 'Blanco' (4). Blanco had light green foliage and white seed which aided in maintaining varietal purity in the seed trade.

The major diseases of blue lupine were brown spot caused by Pleiochaeta setosa, anthracnose caused by Glomerella cingulata and gray leaf spot caused by both Stemphylium solani and S. botryosum (2, 5, 6, 7, 13, 14, 18).

Dr. Forbes and I have screened all land-races and all plant introductions of blue lupine collected through 1975 for brown spot resistance without finding types more resistant than the commonly grown commercial types. We have,

however, found wild types that are more susceptible than the cultivated types. Our methods of screening for brown spot resistance included inoculating plants in moisture chambers in the greenhouse and developing disease nurseries in the field. We also irradiated Blanco seed with X-rays and thermal neutrons and screened approximately 8 acres of M₂ plants without finding additional resistance to brown spot. Fortunately, brown spot can be controlled through rotation; and, if lupine growers follow a rotation in which lupines do not follow lupines, this disease is not too severe (3).

Prior to his retirement in 1952, Dr. Weimer had located a source of resistance to anthracnose in P.I. 168535, an introduction from Portugal. Our early studies showed the P.I. 168535 was either a mixture or was segregating for resistance. Genetic studies demonstrated anthracnose resistance was conditioned by a dominant gene we designated An (5). Further studies demonstrated that the resistance was associated with temperature and would confer resistance at temperatures up to 85 - 90° F whereas the an an, homozygous recessive types were susceptible at 70° F (16). The P.I. 168535 was a slow-growing wild type with small seeds and was bitter. Therefore, our first cross resulted in our having to screen for sweetness, various agronomic characters, and plant types in addition to winterhardiness. Cultivars 'Rancher' and 'Frost' and the advanced breeding line 'Tifblue'-78 all carry the An gene for resistance to anthracnose (7, 11).

In 1956, we discovered gray leafspot resistance in a selection that had been made for its foliage-holding quality at Gainesville, Florida, in 1952 (8, 12). This selection was increased and released by the University of Florida as 'Ritchie', a gray leafspot resistant bitter blue cultivar. Our genetic studies demonstrated resistance was conditioned by the recessive gene gl₁ (12). We crossed Ritchie with our advanced sweet anthracnose resistance lines and combined gray leafspot resistance, anthracnose resistance, and marker genes in our first disease resistant cultivar 'Rancher' (7). Later we found an additional recessive gene gl₂ in a number of wild introductions from Portugal and Spain that was independent of gl₁ and conferred an equal amount of resistance to S. solani and S. botryosum (9, 10). The gl₂ gene is the source of resistance in 'Frost' and both gl₁ and gl₂ are combined in the Tifblue-78 line that is currently being increased for release (11).

Our winters at Tifton were not severe enough to locate the needed winterhardiness in blue lupine during most years. Therefore, we established winterhardiness test nurseries at Calhoun, Griffin and Blairsville, Georgia. R. E. Burns at Griffin and J. W. Dobson at Blairsville have been major contributors to the success of our program. In most years at these three locations the winters were either too mild or too cold to isolate plants with additional winterhardiness. During the winter of 1958-59, after a low temperature of 3° F at Blairsville, Georgia, all blue lupine with the exception of several plants of one introduction were dead. The survivors of this introduction, a selection from P.I. 168535 from Portugal had no stem damage and only moderate leaf-burn. Surviving plants were designated as our winterhardy I (Wh-1) breeding line. Forbes lifted these plants and brought them back to Tifton. In addition to getting a seed increase from these plants in the spring of 1959, they were used as female parents in crosses with our most advanced disease resistant, sweet, and agronomically desirable breeding lines. Fortunately, Wh-1 also carried the gl₂ gene for resistance to gray leaf spot. While it was from the same original P.I. 168535 as our source of anthracnose resistance, this sub-line did not carry the An gene for anthracnose resis-

tance. We have not been able to control temperatures to the extent necessary to determine the genetics of winterhardiness. However, in screening progeny of crosses of Wh-1 x disease resistant lines at both Griffin and Tifton, we have been able to develop 'Frost' and the elite line Tifblue-78 that have the approximate same level of winterhardiness as Wh-1 (6, 11).

Dr. Gladstones, Department of Agriculture, Western Australia, developed seed shatter resistance, tardus (ta) and lentus (le), in blue lupine. He asked to share and select for seed-shatter resistance in segregating populations from appropriate crosses in exchange for the use of our gray leafspot resistance and our screening his progeny for gray leafspot resistance. Out of this international cooperative endeavor, Dr. Gladstones was able to release the seed-shatter resistant, gray leafspot-resistant cultivars 'Marri' and 'Illyriae' in Western Australia; and we have the winterhardy, seed-shatter resistant (ta and le), anthracnose resistant (An), gray leafspot resistant (gl₁ and gl₂), sweet (iuc) cultivar under increase for release in Georgia as Tifblue-78 and a sister line still in test and increase (14).

Our disease screening techniques (8, 12) consisted of inoculating 14-day-old plants with a mixed conidial suspension of S. solani and S. botryosum. The S. solani and S. botryosum inoculum was produced by growing the fungi on 20% V-8 juice agar for 7 days, then scraping off the surface mycelium and placing them under florescent light for 7 more days where an abundance of conidia were produced. Six 9-cm petri dishes of inoculum were placed in ca liter of tap water in a Waring Blender and homogenized for 30 seconds. The suspension was sprayed with an electric vibrator sprayer to run-off on the pre-wet lupine plants in a fog chamber. Plants were kept under intermittent fog for 36 hours and returned to the greenhouse bench. After 3-5 days susceptible plants could be identified, catalogued, and removed. At this stage of development, susceptible plants have characteristic lesions on cotyledons, which is a more definitive symptom than occurs on leaves. Surviving plants were then inoculated with anthracnose grown for 14 days on V-8 Juice agar, homogenized, and sprayed at similar dosage rates as used for the gray leafspot fungus. These plants were kept in fog chambers for 36 hours at ca 75 ° F and moved to a greenhouse bench at ca 75° F for 10-12 days prior to rating. Plants in which petioles and main stems were girdled were rated susceptible whereas plants with only moderate leaf symptoms were rated as resistant. Susceptible plants were removed and survivors re-inoculated with anthracnose. The final survivors were hardened in a cold frame and transplanted to the field for seed increase.

Since gray leaf spot resistance is recessive, progeny testing of survivors was necessary only to identify escapes from the previous year's screening program. Anthracnose resistance is dominant; therefore, progeny testing was used to identify homozygous resistant parents to be advanced in the selection program.

Our screening techniques have confirmed that blue lupines are highly self-pollinated and genetic factors follow typical Mendelian ratios (5, 6, 10). However, as we repeatedly went back to wild types for genetic materials, we found some cross-pollination in our nurseries. This apparently resulted from the fact that some wilt types have softer or more flexible floral parts which our bee populations were able to manipulate to a limited extent.

We now have anthracnose and gray leafspot resistance in such a wide diversity of germplasm so that selective breeding can be made for forage and

grain production without having to go through the long cumbersome greenhouse screening techniques each year to index resistance to these diseases.

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INTRODUCTION AND DOCUMENTATION OF FORAGE CROP GERMPLASM

By George A. White and A. J. Oakes

Since 1898, the U.S. Department of Agriculture has systematically documented information on plant introductions. Later, as an overall national program developed, distribution of materials to germplasm collections for maintenance resulted in vastly improved long-term preservation and subsequent availability of the introduced plant materials. Published plant inventories that contain Plant Introduction (PI) number assignments and associated information start with No. 1 in 1898 and are in print through No. 184 for 1976. As of April 15, 1979, more than 433,000 PI numbers have been assigned.

In a nutshell, the function of the Plant Introduction Office (PIO) is to keep well-documented plant germplasm flowing into U.S. research programs. This activity encompasses all crops and related species. The PIO also coordinates an extensive foreign exchange program. Plant introduction and exchange comprise a logical partnership or marriage as each enhances the other. Conformance to U.S. quarantine regulations and to those of importing countries for plant exchanges is an important ingredient.

PLANT INTRODUCTION AND EXCHANGE

A. Plant Introduction

The Plant Introduction Office is the national focal point for plant introduction. Plant materials are introduced from most foreign countries through correspondence, direct exploration, traveler donations, and through special projects such as the PL 480 Program, Binational Agreements, AID, and others. This office cooperates freely with plant researchers in obtaining needed plant germplasm. Exchanges often open doors to contacts that can provide plant germplasm needed by U.S. scientists.

1. Information documentation - The information on plant introductions is documented along with the PI number assignment. Since February 1979, the documentation has become completely computerized. Information is formatted for computer entry. This formatting, while permitting more flexibility in data retrieval, is noncrop specific because the PIO handles all crop species. After data input, a review copy is printed for technical review by the Plant Introduction Officer and the appropriate agronomic or horticultural germplasm expert. Changes are made, PI numbers assigned, and PI records printed. A copy of the records accompanies the material upon distribution. The records also are transferred to the Washington Computer Center for permanent storage. The manuscript for the annual Plant Inventory can be printed for review on our computer-room printer. The capability exists for the WCC to print the manuscript on camera-ready copy for reproduction. With proper programming, the computer will prepare the scientific and common name index. We can also obtain a print-out summarizing the number of introductions

in several crop categories (forage crops listed as category 30). Accurate source and descriptive information is sought for each accession that receives a PI number. This information becomes a part of a permanent record and should be as accurate and complete as possible

A special feature of the computer program is a plant nomenclature dictionary. Additions and corrections are relatively easy to make. A number code is used to call up the full nomenclature on the video screen for visual verification.

2. Forage germplasm distribution - The responsibility for maintaining working stock collections of all forage species resides with the four Regional PI Stations. Upon completion of information documentation, forage materials are distributed to the appropriate Regional Station (Table 1). These stations are responsible for seed increase, evaluation, documentation of evaluation data, distribution, deposition of a seed sample to the National Seed Storage Laboratory (NSSL), and maintenance of the working stock collection. The number of forage and field crop genera distributed to the Regional Stations and Soil Conservation Service is given in Table 2.

Frequently, samples of seeds and vegetative stocks are sent from foreign sources to U.S. scientists through the Plant Germplasm Quarantine Center. When inclusion in the germplasm collection is desirable, the Plant Introduction Officer contacts the scientists to ask them to share the material to insure its inclusion in the germplasm collection.

B. Foreign Exchange of Plant Germplasm

The U.S. program of exchange, coordinated by the PIO, is supportive of foreign research programs. Small experimental-sized samples for research purposes are sent world-wide free of charge. All materials are channeled through the Plant Germplasm Quarantine Center for inspection and issuance of a phytosanitary certificate. Since foreign import regulations are honored, checking with the PIO before sending plant materials, especially vegetative stocks, is suggested. Forward all materials through the Quarantine Center and enclose the permit if supplied by the foreign requestor. The address of the Quarantine Center is Plant Germplasm Quarantine Center, U.S. Department of Agriculture, Building 320, BARC/East, Beltsville, Maryland 20705, Att: H. R. Hanes. Identify the materials and give the full address of the recipient.

Materials to meet many foreign requests are obtained from the germplasm working stock collections, scientists (for cultivars and breeding lines), and private companies. The PIO is required to write clearance letters when transmitting plant materials to certain countries. Clearance usually requires about two weeks.

QUARANTINE ASPECTS FOR FORAGE SPECIES

A. Introduced Materials

Fortunately, there are few quarantine restrictions on forage species. The most difficult problems are with corn, sorghum, and related species that originate from Africa or Asia and might be used for forage purposes. These species are prohibited except under special quarantine permit. The applicable regulations are to guard against the introduction of downy mildews, rusts, smuts, and viruses. The PIO can usually arrange for proper quarantine handling of a few restricted items.

TABLE 1. Partial listing of forage crop genera maintained by four Regional Plant Introduction Stations (RPIS)

<u>North Central RPIS</u>	<u>Northeastern RPIS</u>
Agrostis	Lotus
Bromus	Phleum
Medicago (perennial)	Trifolium (perennial)
Melilotus	
Panicum	
<u>Southern RPIS</u>	<u>Western RPIS</u>
Cenchrus	Agropyron
Cynodon	Dactylis
Digitaria	Festuca
Elymus	Lolium
Hemarthria	Lupinus (perennial)
Lespedeza	Phalaris
Leucaena	Poa
Lupinus (annual)	Stipa
Medicago (annual)	
Panicum (3 species)	
Paspalum	
Sorghum	
Trifolium (annual)	

TABLE 2. Number of forage and field crop genera distributed to four Regional Plant Introduction Stations (RPIS) and Soil Conservation Service (SCS)

Plant Group	Location				SCS
	North Central RPIS	Northeastern RPIS	Southern RPIS	Western RPIS	
Grasses	23	3	125	46	
Legumes	11	2	61	12	
Other	17	3	23	32	
Total	51	8	209	90	285

Alfalfa seed from Europe requires a seed treatment, and its introduction can be handled through the PIO with the 2100 quarantine label. A permit is required for a scientist to introduce alfalfa seed direct from Europe. The seed must be routed through a quarantine facility for inspection and seed treatment. In the immediate future, a few other species of Medicago from Europe will be added to the Animal Plant Health Inspection Service (APHIS) requirements for seed treatment. Treatment with thiram meets the requirement to protect against exotic strains of Verticillium wilt.

While not commonly used for forage purposes in the U.S., seeds of the genera Glycine, Dolichos, Pachyrhizus, Phaseolus, Pueraria, and Vigna from Africa, Asia, and a few other countries require a seed treatment to guard against the soybean rust organism, Phakopsora pachyrhizi.

Occasionally, samples may be detained by APHIS officials because organisms are detected. Identification of the organisms or other steps may be necessary in order for the detained materials to be released. If exotic, the material may have to be destroyed or be grown under very strict quarantine conditions. APHIS is paying particular attention to viruses in vegetative propagations of grasses. There is also an increasing concern about virus transmittal via legume seeds.

U.S. scientists can apply for quarantine permits to introduce seeds or plants from various parts of the world. Give plant names and the countries involved. Write to the Permit Unit, U.S. Department of Agriculture, Animal Plant Health Inspection Service, PPQ, Federal Building, Room 638, Hyattsville, Maryland 20782.

For experimental quantities of seeds or vegetative stocks, forage researchers are urged to utilize the services of the PIO and the Plant Germplasm Quarantine Center for both the introduction and exchange of forage crop germplasm.

B. Exchanges

Again, quarantine problems of exchanging forage germplasm are relatively minor. Some countries will require import permits. For example, alfalfa seed going to England from the U.S., except California, requires an import permit and field inspection specifying freedom from bacterial wilt. The field inspection but not the permit is required for seed from California. Japan requires microscopic inspection of forage species to guard against a number of organisms. When in doubt about importing country regulations, contact the PIO for assistance.

EXPLORATION FOR FORAGE GERMPLOSM

A. How to Make Proposals

SEA-AR has earmarked funds to support foreign and domestic plant explorations. Procedures for making proposals are available from the Coordinator of the Regional Plant Introduction Station in your region. The addresses of the Regional Stations follow:

North Central
Regional Plant Introduction Station
Iowa State University
Ames, IA 50011

Southern Regional
Plant Introduction Station
Experiment, GA 30212

Northeastern Regional
Plant Introduction Station
Agricultural Experiment Station
Geneva, NY 14456

Western Regional
Plant Introduction Station
59 Johnson Hall
Washington State University
Pullman, WA 99164

Collections are to be incorporated into the National Plant Germplasm Program through PI documentation and distribution to the appropriate Regional Station. When explorations are made through other means of support, collectors are urged to keep the Coordinator of their region and the Plant Introduction Officer informed of plans and to channel the materials through the Plant Germplasm Quarantine Center.

The use of field collector notebooks simplifies PI documentation.

B. Planning an Exploration

The success of plant explorations is dependent largely upon careful planning and organization made before the trip. It is advantageous to establish contact with the USDA Plant Introduction Officer as soon as possible after approval of the exploration. This liaison should be maintained upon return so that the collected germplasm is properly documented and distributed.

In planning your exploration trip, consider the following:

1. Establish contact as early as possible with host country scientists and embassy personnel and obtain formal permission to collect if required.
2. Use available resources such as herbarium samples, information on previous collections, floristic literature, and specialists in the host country and the U.S. to determine distribution and flowering and maturity dates for the species of interest.
3. Take ample and correct supplies and travel aids. Current and detailed maps and addresses of universities and experiment stations are invaluable. Supplies should include seed packets, bags for vegetative and large seed samples, smear-proof markers, field notebooks, altimeter and compass, vials for rhizobia, small hand tools, a camera, quarantine mailing labels and a permit if required.
4. Work out methods for sending materials back in advance. This is very critical for vegetative stocks.
5. Share, as appropriate, part or all of your collection with the host country. Some countries may require sharing.

C. Assistance with Explorations

The Plant Introduction Officer and agronomic crop germplasm specialist, Germplasm Resources Laboratory, provide assistance as needed for agronomic crop explorations. Simply stated, available helps include:

1. Assistance with all quarantine and shipping aspects.

2. Establishment of contacts and clearance letter requirements.
3. Supplies such as field collector notebooks, quarantine labels, altimeters, etc.

D. Examples of Explorations and Other Forage Collections

1. Foreign explorations for forage crop species since 1970.

Year	Summary of Collection
1971	South Africa. Warm-season grasses, primarily <u>Digitaria</u> . A. J. Oakes. 900 accessions.
1972	Iran. <u>Agropyron</u> . D. R. Dewey & J. L. Schwendimen. About 2,200 accessions.
1974	Morocco, Portugal, Spain, Tunisia. I. Forbes. <u>Lupinus</u> , <u>Ornithopus</u> , and <u>Trifolium</u> . 431 accessions.
1975	France, Spain, Portugal, Morocco. <u>Festuca</u> , other grasses and legumes. J. R. Powell. 450 accessions.
1975	Brazil, Paraguay, Uruguay. <u>Paspalum</u> and legume species. B. L. Burson & W. R. Langford. 720 accessions.
1976	South Africa. Warm-season grasses and legumes, primarily <u>Cenchrus</u> . E. C. Bashaw & A. J. Oakes. 1300 accessions.
1977	Greece, Crete, Italy, and Switzerland. <u>Trifolium</u> and others. R. R. Smith & W. R. Langford. 361 accessions.
1978	Russia. <u>Agropyron</u> , <u>Elymus</u> , and forbs. D. R. Dewey & P. Plummer (Forest Service). About 900 forage accessions.
1978	Central America, Mexico. <u>Leucaena</u> . J. L. Brewbaker & A. J. Oakes. 400 accessions.
1979	Argentina, Brazil, Bolivia. <u>Paspalum</u> . B. L. Burson. About 650 accessions.
1979 (planned)	Yugoslavia. <u>Dactylis</u> , <u>Festuca</u> , <u>Trifolium</u> . R. Haaland.

2. Other collections of interest

As part of the United States-Japan Natural Resources Project, over 700 accessions have been introduced and incorporated into the Regional Station collections. Small Dactylis collections by Dr. Kawabata of Japan from Iran and Turkey will be introduced later this year. Recently, a small collection of forage carrots was donated by the Netherlands. The Plant Introduction Officer has requested information about a large Spanish collection of annual Medicago and Trifolium species.

SPECIAL MAINTENANCE PROBLEMS

Maintenance of clonal materials poses a major problem and considerable germplasm has been lost as recently as the last 10-15 years. Whenever possible, forage germplasm should be maintained as seed. A subtropical

location to supplement the four Regional Plant Introduction Stations would greatly reduce the mortality level of forage vegetative stocks. All too frequently, the material will not set seed and may be poorly adapted to the maintenance area. Such clonal maintenance requires sustained effort and support.

SUMMARY

Forage crop germplasm is a resource of vital importance to forage researchers. The Germplasm Resources Laboratory and, in particular, the Plant Introduction Office services both the introduction and exchange of such materials. Quarantine regulations of the U.S. and of importing countries for exchanged materials are followed. Information on introduced and domestically collected forage germplasm is documented in published Plant Inventories. Forage species are distributed on a priority basis to four Regional Plant Introduction Stations. Back up support for plant explorations is available.

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THE SEA-AR FOUNDATION SEED PROJECT

By Aref A. Abdul-Baki and Florence M. Cox

BACKGROUND

The SEA Foundation Seed Project which is coordinated by the Seed Research Laboratory at the Beltsville Agricultural Research Center was approved in 1948 and has operated continuously to date. The purpose of the Project is still to "build up quickly and to maintain foundation seed of superior grass and legume varieties". The operational phases are concerned only with producing, assembling, distributing and limiting stockpiling of foundation seed. The Project is supported jointly by Agricultural Research and the Commodity Credit Corporation. A Memorandum of Understanding between the former Agricultural Research Service and the Agricultural Stabilization and Conservation Service, representing CCC, was signed in May 1949. The most recent revision of the M/U was approved on October 5, 1970.

The Project continues to play an important role in the rapid multiplication of many improved forage varieties used extensively in the humid regions of the country. Without this program some varieties would not be making the contribution to livestock feed production as is currently the case; others would have been available to farmers only in limited supply.

In the mid-40's, superior forage varieties were grown on less than two percent of the acreage. A study by Administrators in the U.S. Department of Agriculture and the State agricultural experiment stations showed the major factors responsible for this situation were:

1. The failure to develop seed production programs for many small seeded grass and legume varieties in favorable environments in the Western States; this is in contrast to the local production of cereals and oilseed crops.
2. No organized program for the production and maintenance of inventories of foundation seed of the superior varieties.
3. Inadequate educational programs.

These three factors have the same importance today as they did 30 years ago although some states have expanded their foundation forage seed activities. Each has a significant bearing on the success of varietal releases from public breeding projects. Inadequate educational programs emphasizing improved varieties is still a major limitation.

The SEA Foundation Seed Program has built up and maintained foundation seed of forage crop varieties used extensively in the Central, Eastern, and Southern States. To facilitate the maximum increase of new grass and legume varieties, the Foundation Seed Program is authorized to assist breeders in maintaining breeder seed and, as may be necessary, to accumulate small supplies of registered seed. During the many years of operating this program, CCC has not sustained any long-term financial losses. In fact, there has been a small

net gain of \$300,000 to \$400,000 during the period. AR participation is covered by funds appropriated annually.

The operational phases of the program, namely, production, processing, storage, and distribution of foundation seed is cooperative with State agricultural experiment stations, State seed certifying agencies, State foundation seed organizations, and seed firms. Each cooperating agricultural experiment station assigns a State foundation seed representative to assist with Project operations in that State. A simplified scheme showing the various organizations involved in the program appears in Figure 1.

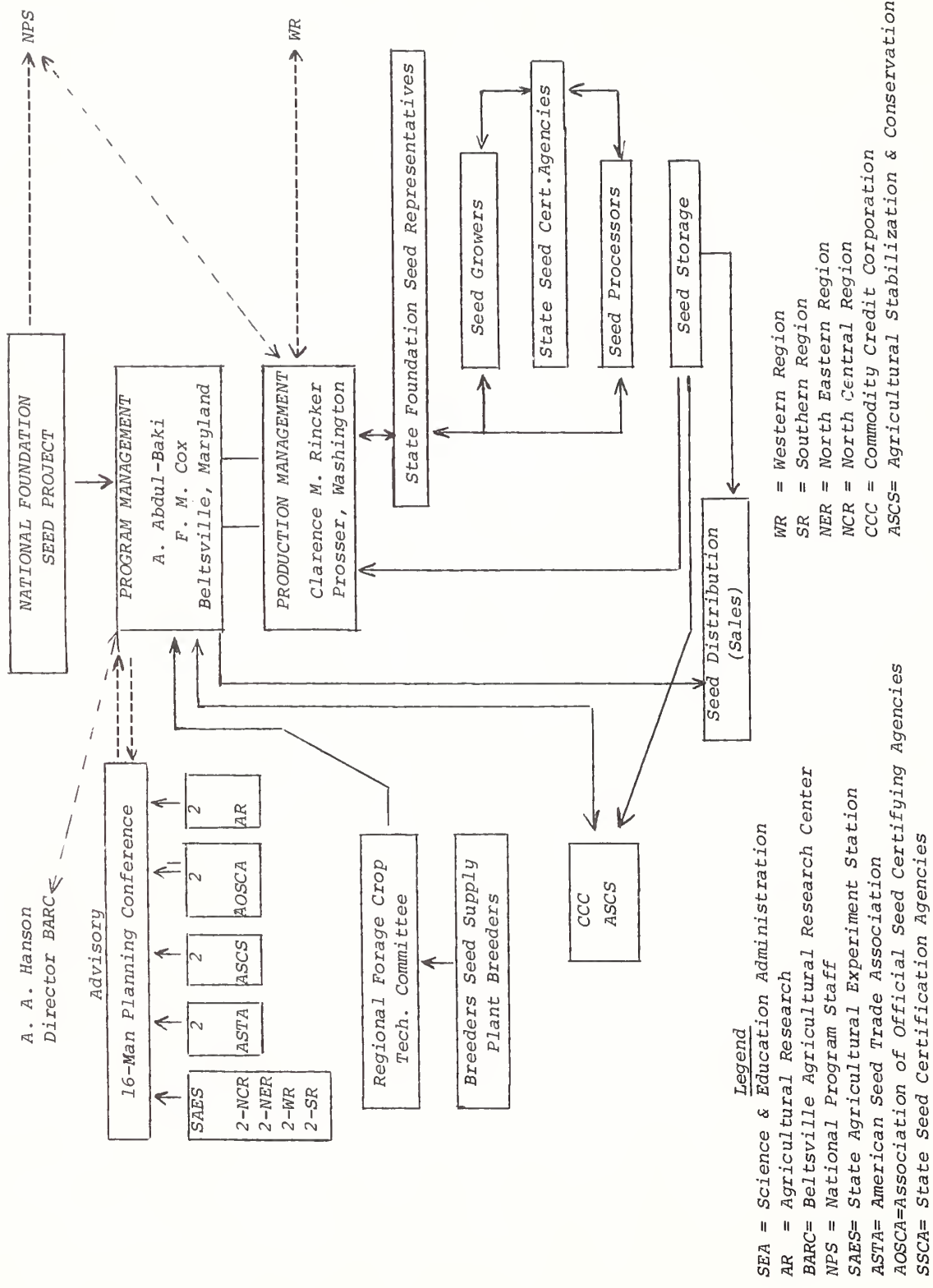
The production and distribution of adequate and recurring supplies of foundation seed is the final stage in the breeding and release of superior varieties. This type of support program is required if the investment in forage breeding is to pay dividends by increasing feed production efficiency. Frequently, new varieties are not multiplied in the quantity needed to meet demand because of inadequate foundation seed. Such varieties as Cumberland and Midland red clover; Atlantic and Buffalo alfalfa; Tift sudangrass; and Climax lespedeza failed to meet their full potential because efforts to produce foundation seed were "too little and too late".

On the other hand, Vernal alfalfa was taken into the Foundation Seed Project at the time of its release in 1951. Eighteen months later there were over 1.8 million pounds of certified seed. In comparison, only 1.1 million pounds of certified Ranger and 14,568 pounds of certified Atlantic Alfalfa seed were produced six and eight years after the release of these two varieties. The maintenance of foundation seed supplies has made Vernal the most widely used alfalfa variety in the U.S. today. To date more than 300 million pounds of certified Vernal have been produced. This quantity is second only to the record for Ranger which is nearly one billion pounds.

Certified seed of Cumberland red clover never was available in adequate supply because stock seed was continually siphoned off and used for forage plantings in the Eastern States. If there had been a program to maintain recurring supplies of foundation seed, this variety would have been used extensively for hay and pasture. Midland red clover adapted to the North Central States fell by the wayside for the same reason. A committee of the International Crop Improvement Association (AOSCA) tried to coordinate supplies of foundation seed. However, because of limited financial resources, it could not build up and maintain reserves of foundation seed.

Another example of the importance of an adequately financed foundation seed program is the success achieved with Gahi 1 pearl millet. This variety was developed by SEA-AR at the Georgia Coastal Plains Experiment Station and released for use in the Southwestern States. Foundation seed supplies have been maintained by the Project. In 1963, there was an extensive campaign to encourage the planting of sudan-sorghum hybrids on the Coastal Plain soils of the Southeast. This resulted in a sharp decline in the demand for foundation Gahi 1, which fell to zero in 1965. However, the Foundation Seed Project retained its inventories. Thus foundation seed stocks were available three years later when demand for planting stock seed rose dramatically following the poor performance of sudan-sorghum hybrids on the light soils of the Southeast. In the late 1960's certified Gahi 1 seed prices dropped severely so that it was not profitable for many growers to produce seed. This was accompanied by a reduction in demand for foundation seed. Again, the Project maintained seed reserves, and in 1973 was able to meet the largest demand to date for foundation Gahi 1 seed. Thus, the Project not only maintains

USDA, SEA-AR



Legend

- SEA = Science & Education Administration
- AR = Agricultural Research
- BARC= Beltsville Agricultural Research Center
- NPS = National Program Staff
- SAES= State Agricultural Experiment Station
- ASTA= American Seed Trade Association
- AOSCA=Association of Official Seed Certifying Agencies
- SSCA= State Seed Certification Agencies
- WR = Western Region
- SR = Southern Region
- NER = North Eastern Region
- NCR = North Central Region
- CCC = Commodity Credit Corporation
- ASCS= Agricultural Stabilization & Conservation Service

Figure 1.--Structured organization of the SEA-AR-National Foundation Seed Project.

foundation seed supplies for current distribution but also carry-over inventories to assure availability of planting stocks over the long term. If this were not done, varieties such as Gahi 1 could be lost to agriculture.

Many seed firms which have their own breeding programs are interested primarily in the production, distribution, and promotion of their proprietary varieties. They are not interested in handling seed of publicly bred varieties unless they were granted exclusive rights to these varieties. For example, the initial foundation seed of Apalachee alfalfa from the North Carolina Agricultural Experiment Station was released to two seed firms for multiplication and distribution in the area of usage. Four years later there was no reported production of certified seed from these releases. The new Arc alfalfa was released in 1974, 50 percent of the 417 pounds of reclassified breeder seed was distributed through State foundation seed programs, the remainder through two seed firms. The former was planted and most of the acreage produced a seed crop in the seedling year. Foundation seed distributed to seed firms was not planted until late 1974. According to reports, the firms were too involved with proprietary varieties to arrange for the multiplication of Arc seed.

Varieties developed by SEA-Agricultural Research in cooperation with State agricultural experiment stations are not likely to be released on an exclusive basis in the near future. Since large seed firms have proprietary varieties which give them exclusive marketing rights, they are not interested in maintaining the foundation seed reserves of non-exclusive public varieties which must be distributed on an equitable basis to all qualified growers who request seed. However, a large number of smaller seed firms depend on public-released varieties to maintain their position in the market place.

PAST OPERATIONS

Table 1 lists the varieties, introduction year into the program, and total production of foundation seed up to 1978 production year. It should be noted that seed production was less than the demand for most varieties. Failure due to unfavorable weather conditions in certain years lead to severe but temporary shortages which were corrected in the following year.

PRESENT OPERATIONS

Table 2 summarizes total production, sales, and carryover of foundation seeds over the past two years (1977-1978). The year 1978 was an exceptionally poor production year. The growing season was very dry, harvest time for grasses was wet, and the winter that followed was exceptionally cold. As a result, low yields were obtained from certain crops and complete, or near failure with others, particularly red clover varieties.

In order to build an adequate stockpile, particularly for seed of varieties that were sold completely, we have contracted for new and additional acreages. Table 3 lists pending new production controls for alfalfa, red clover, and tall fescue. In addition, we have recommended 20 additional acres to be contracted in the fall of 1979 for each of Arlington, Kenland, and Kenstar red clover. Unless we encounter another unfavorable production year, these measures should build seed reserves to a satisfactory level.

In conclusion, the demand for foundation seed of varieties multiplied under the National Foundation Seed Project is increasing year after year. We are making every possible effort to meet the demand by producing seeds in the

Table 1. Year of introduction, production, and current inventory of varieties currently in the Foundation Seed Project

Species	Variety	Year of introduction into Fd. Seed Prj.	Foundation seed produced lbs.	Current * inventory lbs.
<u>Alfalfa</u>	Agate	1974	81,157	24,289
	Apalachee	1972	654	160
	Arc	1974	66,846	3,250
	Ramsey	1974	6,921	4,501
	Vernal	1951	<u>1,742,934</u>	<u>113,769</u>
Subtotal			<u>1,898,512</u>	<u>145,969</u>
<u>Red clover</u>	Arlington	1974	55,379	0
	Kenland	1949	1,064,436	0
	Kenstar	1974	98,678	2,500
	Lakeland	1961	433,406	39,892
	Pennscott	1950	<u>700,009</u>	<u>4,917</u>
Subtotal			<u>2,351,908</u>	<u>47,309</u>
<u>White clover</u>	Tillman	1969	<u>1,255</u>	<u>300</u>
Subtotal			<u>1,255</u>	<u>300</u>
<u>Orchardgrass</u>	Potomac	1954	<u>190,612</u>	<u>15,219</u>
Subtotal			<u>190,612</u>	<u>15,219</u>
<u>Tall fescue</u>	Kenhy	1977	0	0
<u>Pearl millet</u>	Starr	1957	130,618	9,100
	Gahi I Lines #13,#18,#23,#26 Blends		<u>399,637</u>	<u>5,476</u>
Subtotal			<u>530,255</u>	<u>14,576</u>
TOTAL			4,972,542	223,373

*As of April 1979

Table 2. Production, sales, and carryover of foundation seeds over the 1977-1978 production years

Species	Variety	Carryover from 1976 lbs.	1977 production lbs.	Total lbs.	1978 sales lbs.	Carryover to 1979 lbs.
Alfalfa	Agate	26,220	9,897	36,117	9,050	27,067
	Arc		13,512*	13,512	13,512	0
	Apalachee	160	0	160	0	160
	Ramsey	602	3,899	4,501	0	4,501
	Vernal	163,668	0	163,668	40,899	122,769
Red clover	Arlington	No foundation Arlington seed - 1978				
	Kenland	350	10,183	10,533	10,533	0
	Kenstar	15,129	7,931	23,060	23,060	0
	Lakeland	62,552	0	62,552	20,620	41,932
	Pennscott	0	12,392	12,392	10,050	2,342
White clover	Tillman	420	0	420	120	300
Pearl millet	Gahi I	3,350	19,926	23,376	11,800	11,476
	Starr	10,100	0	10,100	0	10,100
Tall fescue	Kenhy**	No foundation seed for 1977-78				
Orchardgrass	Potomac***	15,389	9,000	24,389	15,130	9,264

*Substandard seed due to low germination. Seed purchased and sold at lower price than foundation seed.

**Failed to meet foundation seed standards due to inclement weather.

***9,000 lbs. were produced in 1978; 3,030 lbs. were sold in 1979 with a present balance of 15,219, April 1979.

quantities needed and by building up a stockpile which will guarantee the availability of seeds for one or two years should a failure in seed production occur at any time in the future.

Table 3. 1979 Production Contracts

Species	Cultivar	Acres	Grower
Alfalfa	Arc	110	Seibel Bros., Oregon (60) Horse Haven, Washington (50)
	Agate	26	Beach Farms, Washington
Red clover*	Arlington	38	Amos Hays & Son, Washington
	Kenland	18	Vern Rudberg, Washington 15 acres planted by Schempp Bros., Washington, plowed out, poor stand
	Kenstar	38	D. Grebb, Washington
	Pennscott	28	J. W. Brieder, Washington
Tall fescue	Kenhy**	22	Irwin & Sons, Oregon

*Twenty additional acres have been recommended to be contracted for Arlington, Kenland, Kenstar.

**No 1977 production of Kenhy - inclement weather caused crop failure. 1978 production of Kenhy failed to meet foundation seed standards. For distribution, 3,100 lbs. of Kenhy was made available to us by the Kentucky Experiment Station, Lexington, in 1977, and 2,500 lbs. in 1978.

ENCROACHMENT OF COMMON BERMUDAGRASS (Cynodon dactylon L.)

IN SUBTROPICAL AND TROPICAL PERENNIAL GRASSES

By P. Mislevy

Forage producers in central and south Florida fight a constant battle with common bermudagrass (Cynodon dactylon L.) trying to keep this persistent weedy plant from taking over perennial tropical grasses. When introduced grasses are established on land prepared from native conditions, they may persist and remain relatively pure for about a decade. However, if Digitaria spp. are re-established on land which has been in improved pasture for 20 to 30 years and is infested with common bermudagrass, success longer than 2 to 4 years is unlikely.

Recent studies by Mislevy and Hodges (3) and Adjei et al. (1) indicated that common bermudagrass occupied 50 to 90% of pastures containing 'Pangola' digitgrass (Digitaria decumbens Stent.) 'Slenderstem' digitgrass (D. pentzii Stent.) and 'Transvala' digitgrass (D. decumbens Stent.) after two years or less of grazing. Improved grasses belonging to other genera such as Cynodon and Paspalum appear to be much more persistent and competitive with common bermudagrass. Recent observations by Mislevy in a mob-grazing study indicated several Cynodon entries contained less than 5% common bermudagrass after three years of grazing. Pangola and Transvala digitgrass plantings about 1 meter from the Cynodons were replaced by common bermudagrass which covered more than 90% of the plot. A similar succession has been observed in harvested plot studies, however a longer period of time was required for complete transition to the weedy grass.

Many theories such as competition, weak root system, carbohydrate depletion, winter-killing, etc. have been expressed trying to explain the transition. Common bermudagrass is the only strongly stoloniferous perennial grass which spreads by seed and rhizomes simultaneously. This species can tolerate shade, low fertility, and excessive moisture conditions. Further competitive advantage accrues from low palatability in central and south Florida. When common bermudagrass and Digitaria exist in the same pasture, a grazing differential results with Pangola overgrazed and common bermudagrass grazed very little. These built-in defense mechanisms allow common bermudagrass to withstand many diverse edaphic, climatic, and physical conditions.

Several researchers (Martin and Rademacher, 2; Muller, 4) have used the term allelopathy to describe the harmful effect of one higher plant on another through the production of chemical retardants. Rice (5) indicated the term allelopathy should include any direct or indirect harmful effect by one plant (including micro-organisms) on another through the production of chemical compounds that escape into the environment. The difference between allelopathy and competition is the allelopathy depends on chemical compounds which are added to the environment by plants (perhaps by common bermudagrass), while

competition involves the reduction of light, water, etc. from the environment for plant growth.

There is a need to study the effect of competition, allelopathy, etc. on encroachment of one species of higher plant on another under natural conditions.

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- Abdul-Baki, Aref A., chief, Seed Research Laboratory, Science and Education Administration, U.S. Department of Agriculture, Beltsville Agricultural Research Center, Beltsville, Md. 20705
- Barton, F. E., II, research chemist, Science and Education Administration, U.S. Department of Agriculture, Richard B. Russell Research Center, P.O. Box 5677, Athens, Ga. 30604
- Bond, J., research animal scientist, Science and Education Administration, U.S. Department of Agriculture, Beltsville Agricultural Research Center, Beltsville, Md. 20705
- Bouton, J. H., assistant professor, University of Georgia, Athens, Ga. 30602
- Burdick, Donald, chief, Field Crops Laboratory, Science and Education Administration, U.S. Department of Agriculture, Richard B. Russell Research Center, P.O. Box 5677, Athens, Ga. 30604
- Burns, Joe D., associate professor, University of Tennessee, Knoxville, Tenn. 37901
- Chaney, R. L., plant pathologist, Science and Education Administration, U.S. Department of Agriculture, Beltsville Agricultural Research Center, Beltsville, Md. 20705
- Clark, Ed, associate professor of botany, Auburn University, Auburn, Ala. 36830
- Cox, Florence M., secretary to lab chief, Seed Research Laboratory, Science and Education Administration, U.S. Department of Agriculture, Beltsville Agricultural Research Center, Beltsville, Md. 20705
- Davidson, J. R., Department of Veterinary Science, University of Maryland, College Park, Md. 20742
- Decker, A. M., professor, Agronomy Department, University of Maryland, College Park, Md. 20742
- Elgin, J. H., Jr., research agronomist, Science and Education Administration, U.S. Department of Agriculture, Beltsville Agricultural Research Center, Beltsville, Md. 20705
- Evans, J. Kenneth, extension specialist in forages, College of Agriculture, University of Kentucky, Lexington, Ky. 67213
- Faust, Robert M., research entomologist, Science and Education Administration, U.S. Department of Agriculture, Beltsville Agricultural Research Center, Beltsville, Md. 20705
- Foy, C. D., soil scientist, Science and Education Administration, U.S. Department of Agriculture, Beltsville Agricultural Research Center, Beltsville, Md. 20705
- Goering, H. Keith, research animal scientist, Science and Education Administration, U.S. Department of Agriculture, Beltsville Agricultural Research Center, Beltsville, Md. 20705
- Gray, Fred, plant pathologist and nematologist, Cooperative Extension Service, Auburn University, Auburn, Ala. 36830
- Haaland, R. L., assistant professor, Department of Agronomy and Soils, Auburn University, Auburn, Ala. 36830

Hammond, R. C., Department of Veterinary Science, University of Maryland,
College Park, Md. 20742

Horner, E. S., professor of agronomy, University of Florida, 304 Newell Hall,
Gainesville, Fla. 32611

Hoveland, C. S., professor, Department of Agronomy and Soils, Auburn University,
Auburn, Ala. 36830

Kalmbacher, R. S., assistant agronomist, University of Florida, Agricultural
Research Center, Ona, Fla. 33865

Lippke, Hagen, associate professor, Texas Agricultural Experiment Station, P.O.
Box 728, Angleton, Tex. 77515

McLaughlin, M. R., Department of Plant Pathology, Clemson University, Clemson,
S.C. 29631

Miller, R. W., research animal scientist, Science and Education Administration,
U.S. Department of Agriculture, Beltsville Agricultural Research Center,
Beltsville, Md. 20705

Mislevy, P., associate professor, Department of Agronomy, University of Florida,
Agricultural Research Center, Ona, Fla. 33865

Moe, P. W., supervisory research animal scientist, Science and Education Admin-
istration, U.S. Department of Agriculture, Beltsville Agricultural Research
Center, Beltsville, Md. 20705

Mohanty, S. B., Department of Veterinary Science, University of Maryland,
College Park, Md. 20742

Moutray, Jim B., director of forage research, N.A.P.B., Route 3, Ames, Iowa
50010

Nafus, D. M., research animal scientist, Science and Education Administration,
U.S. Department of Agriculture, Beltsville Agricultural Research Center,
Beltsville, Md. 20705

Nelson, Billy D., associate professor, Franklinton, La. 70438

Norris, Karl H., chief, Instrumentation Research Laboratory, Science and Educa-
tion Administration, U.S. Department of Agriculture, Beltsville Agricul-
tural Research Center, Beltsville, Md. 20705

Oakes, A. J., research agronomist, Science and Education Administration, U.S.
Department of Agriculture, Beltsville Agricultural Research Center, Belts-
ville, Md. 20705

Pickens, L. G., research animal scientist, Science and Education Administration,
U.S. Department of Agriculture, Beltsville Agricultural Research Center,
Beltsville, Md. 20705

Powell, J. B., geneticist, Science and Education Administration, U.S. Department
of Agriculture, Beltsville Agricultural Research Center, Beltsville, Md.
20705

Pratt, Robert G., research agronomist, Science and Education Administration,
U.S. Department of Agriculture, P.O. Drawer PG, Mississippi State, Miss.
39762

Ratcliffe, Roger H., research entomologist, Science and Education Administration,
U.S. Department of Agriculture, Beltsville Agricultural Research Center,
Beltsville, Md. 20705

Rodriguez-Kabana R., professor, Botany and Plant Pathology Department, Auburn
University, Auburn, Ala. 36830

Rumsey, T. S., research animal scientist, Science and Education Administration,
U.S. Department of Agriculture, Beltsville Agricultural Research Center,
Beltsville, Md. 20705

Shenk, J. S., associate professor, Department of Agronomy, Pennsylvania State
University, University Park, Penn. 16802

Stephens, Walter, Route 4, Tifton, Ga. 31794

Templeton, W. C., Jr., research agronomist, Science and Education Administration,
U.S. Department of Agriculture, U.S. Regional Pasture Research Laboratory,
University Park, Pa. 16802

Thompson, Warren C., North American Plant Breeders and AFGC, 121 Dantzler Ct.,
Lexington, Ky. 40503

Vaughn, James L., research entomologist, Science and Education Administration,
U.S. Department of Agriculture, Beltsville Agricultural Research Center,
Beltsville, Md. 20705

Waldo, D. R., research animal scientist, Science and Education Administration
U.S. Department of Agriculture, Beltsville Agricultural Research Center,
Beltsville, Md. 20705

Wells, Homer D., research plant pathologist, Science and Education Administration,
U.S. Department of Agriculture, Georgia Coastal Plain Experiment Station,
Tifton, Ga. 31794

White, George A., chief, Germplasm Resources Laboratory, Science and Education
Administration, U.S. Department of Agriculture, Beltsville Agricultural
Research Center, Beltsville, Md. 20705

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