Report of the

External Review Team

BEEF PRODUCTION SYSTEMS PROGRAM

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CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL
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0.0 FOREWORD

This is a report of the Beef Cattle Review Team invited by CIAT to examine and evaluate the Soil-Pasture-Animal Program and to assist in the further development of research and training in beef cattle production.

The review was made during April 30-May 14, 1973, with an oral report given to the Board of Directors on May 15, 1973. Details of places visited and persons contacted are given in Appendix A. Briefly, five days were spent in Colombia, five in Brazil and five back in Colombia discussing and preparing the report.

The Review Team Members wish to commend the Beef Cattle Staff of CIAT on their integrated Soil-Plant-Animal approach, the development of program objectives, project proposals, and implementation of problem-oriented field research. Personal thanks go to the officials and staff members of institutions visited. Special acknowledgment is noted for the CIAT Staff of the Beef Cattle Program who provided useful explanations of their research and who accompanied us on trips.

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1.0 INTRODUCTION

1.1 Purpose of Review

A great deal of planning went into the establishment of CIAT. The 1966 Roberts and Hardin report[1/] established the basic rationale of and need for such a center with major emphasis on livestock in the lowland tropics. In 1968 Crowder and Blazer made recommendations relative to potential Forage and Pasture Programs[2/].

In early 1968 a New York seminar on directions and priorities for the livestock program attracted an attendance representative of a broad range of expertise and of numerous countries of the lowland tropics[3/]. In August 1968 CIAT, recognizing the need to focus its efforts on major problems and opportunities in the livestock area, invited a team of experts to visit various programs in Latin America to determine the status of livestock research and training programs in the lowland tropics and to recommend priorities and approaches for the CIAT livestock program[4/]. Others provided recommendations for other phases of the CIAT program and in 1968 CIAT prepared a comprehensive development plan[5/].

Planning is a continuous process. Thus it is not surprising that in early 1973, with approximately four years of research and training background, CIAT again invited a team, representative of a wide range of subject matter disciplines essential

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1/ L.M. Roberts and L.S. Hardin. 1966. A proposal for creating an International Institute for Agricultural Research and Training to serve the lowland tropical regions of the Americas.

2/ L.V. Crowder and R.E. Blazer. 1968. Pasture-Livestock Research and Training Program.

3/ Centro Internacional de Agricultura Tropical. 1968. Report of Group Review of Animal Science Program for International Centers of Tropical Agriculture (April 23-24, 1968).

4/ J.J. Callis, J.T.Gallo, L.J. Lambourne, H.H.Stonaker and K.L.Turk. 1968. Livestock Research and Training Program of CIAT. Report of the Animal Sciences Review Team (presented on August 24, 1968).

5/ Centro Internacional de Agricultura Tropical. 1968. Proposed Program, Staff and Budget.

to the CIAT program, to review the program and to make recommendations relative to priorities and directions. The Director General of CIAT, Dr. U.J. Grant, was specific in his charge to the team. Dr. Grant requested that the team (1) evaluate present programs and objectives of CIAT, (2) identify relevant areas for program emphases and priorities, (3) recommend priorities for work between alternative areas and locations, (4) evaluate the transferability of results from different locations, (5) consider potential outreach programs, and (6) analyze and recommend the timing and content of potential new programs.

Dr. Grant emphasized the desire on the part of CIAT for a thorough, objective analysis and invited minority views in the event the team found itself in less than full agreement. An oral report to the CIAT Board of Directors was requested for May 15, 1973 with a written report to follow.

1.2 Plan of the Report

During and following visits to various research and training sites in Colombia and Brazil, the team had extensive conferences with CIAT staff and administration and with professionals working in the various institutions visited in Colombia and Brazil. The itinerary of the team in Colombia and Brazil is given in Appendix A. In Appendix B, a list of non-CIAT staff interviewed is presented. In addition, both during and after the research and training site visits the team engaged in extensive and intensive discussions of what it considered to be the relevant issues.

This report is essentially a summary of the team's response to the charge given it by CIAT. Following this brief introduction, major features of the CIAT livestock feed production work are reviewed and recommendations offered. The Center's beef production program is then similarly treated. Next feed production and livestock interrelationships are treated under the title of Production Systems.

Training is an integral part of the CIAT Program. However, training is sufficiently specialized to require a section of analysis and recommendations regarding specific training programs. Particular attention is given to audience identification, subject matter content, and training format.

Outreach is a major challenge of an international center such as CIAT, thus such a discussion is included.

Recommendations relative to feed production, beef production, production systems, training and outreach have implications for CIAT staffing and for location of work. Finally, a summary of the Team's analyses and recommendations is provided.

1.3 Objectives of CIAT

The major objective of the CIAT Beef Cattle program is to increase cattle productivity in the lowland tropics of Latin America between the Tropics of Cancer and Capricorn and at elevations below 1000 m. To achieve this objective CIAT is applying available and relevant information and technology and is identifying and finding solutions to the special cattle problems of this vast tropical area. Discovering techniques for economic production of beef in vast areas of high acidity, low fertility soils unlikely to be used for crops is the first priority. Successful techniques will provide more protein, jobs, and incomes for the people of the various countries and will stimulate the development of thinly populated and relatively unused areas. They will also be reflected in the amount of beef available for export from the various countries and in the resulting enhanced economic growth rates.

CIAT management and staff recognize that a marked increase in cattle productivity requires a greatly increased year round supply of digestible energy, protein, and minerals from pastures and forages. To achieve this, native species will have to be supplemented with improved legume-grass pastures fertilized mainly with superphosphate. However, CIAT is aware that it is likely to be many years before native grazing lands will contain a high percentage of improved pasture. Thus, techniques for increasing animal productivity on native pastures are regarded as essential and are being integrated into beef production systems involving improved pastures and forages, and crops where appropriate.

In view of the needs of the beef cattle industry of the lowland tropics CIAT's main research objectives in the beef program are:

(1) To raise the quantity and quality of the feed supply,

(2) To control diseases and parasites that limit production potential,

(3) To devise production systems which produce good quality beef efficiently and cheaply.

An important activity complementary to CIAT's research program is the training of beef cattle research and production specialists from the tropics of Latin America. This perhaps is the quickest and most efficient method of ensuring the adoption throughout the area of the new and progressive practices being developed by CIAT.

It is the opinion of the Beef Cattle Review Team that CIAT's research and development objectives have generally been clearly stated and given the proper priority and emphasis. However,due to limited staff resources, particularly in the area of pasture seed production and establishment, the research to find methods of increasing the supply of quality feed through pasture improvement has been retarded.

1.4 Progress to Date

The Board of Directors, management and staff of CIAT can be justly proud of the excellent progress that has been made in the beef program of CIAT during its early years of operation. Long range and immediate objectives have been identified and programs structured to achieve these objectives. Further, a competent, committed staff has been recruited to carry out the program. The ICA research station at Carimagua has been developed in a remarkably short period of time. Further, the CIAT facilities at Palmira are well underway. It is particularly noteworthy that management and staff have made extremely effective use of interim accomodations so that the beef cattle program has been developed without awaiting completion of permanent facilities.

2.0 FEED PRODUCTION

Low quality herbage and lack of nutritious feedstuffs during the dry season place serious constraints on increased livestock production in the tropics. Natural and naturalized grazing lands are mainly comprised of grasses in mixture with herbaceous and woody species, usually having few or no legumes. Improved and fertilized legume-grass pastures are frequently more tolerant of the droughty conditions than native grazing lands and often provide sufficient digestible energy and protein to maintain weight of grazing cattle during these periods of stress. The semi-starvation of livestock during the dry season in the lowland tropics could be ameliorated with establishment of improved pastures. Legumes and grasses are presently available and their benefit for increased animal output have been demonstrated experimentally. CIAT should assume the leadership in extending their establishment and utilization.

2.1 Collection, Selection and Evaluation of Legumes and Grasses

The team enthusiastically, endorses the rapid move to collect, introduce, and evaluate an array of legumes suitable as pioneer species (e.g. Stylosanthes guyanensis) as well as those adapted to improved soil fertility conditions (e.g. Centrosema pubescens). The collection of local legumes types should be intensified and broadened to include other species, especially Leucaena leucocephala. The latter is capable of producing high protein forage (up to 30 percent crude protein) in the dry season because of deeply penetrating roots which tap moisture in the lower soil layers. With a sufficient area of Leucaena, cattle could be better maintained in the dry season. Lines coming from the CSIRO legume improvement program at Brisbane, Australia should be obtained and evaluated.

The potential of Paspalum plicatulum, which was earlier observed at the ICA "La Libertad" Station and confirmed at the Carimagua Station, along with the use of Melinis minutiflora (Molasses grass) provide an initial step in replacing native grasses with more productive species. As soil fertility is progressively increased, other species with higher yield potential can be substituted. One of these is Panicum maximum (guinea grass) which possesses many different genotypes having a broad

array of phenotypic expressions in regard to plant types. A large collection of Panicum located at the ORSTOM Station at Adiopodumé, Ivory Coast, contains a remarkable diversity of germplasm. An effort should be made to obtain seed for testing by CIAT under different environments. It will be necessary to have permission from the Director of ORSTOM in Paris to secure seed samples but this could no doubt be done through appropriate channels.

Most tropical American agricultural institutions collect and maintain grass and legumes introduction gardens. These need to be surveyed for materials not present in the CIAT pasture species collection. Additional effort should be made to enlist the collaboration of staff of national pasture and forage programs to assist in the collection of local legumes and grasses. The search might be extended to Africa by proper contacts with the IITA plant exploration team in their collecting trips for food legumes, root, and tuber crops.

There is an ever-pressing urgency for immediate attention to collecting legumes and grasses in view of the rapid expansion of arable agriculture into regions heretofore not opened for farming. Once these frontierlands are brought under cultivation valuable germplasm will be lost forever.

Legume and grass species and biotypes identified by CIAT as having genetic and agronomic potential to improve pasture output should be rapidly moved into regional evaluation trials and grazing studies in collaboration with national pasture and forage programs. CIAT staff can provide a service in the coordination of such trials and in the standardization of evaluation procedures and techniques. Undoubtedly, the Training Program can expedite regional testing and evaluation as trainees return to their respective countries.

The few improved tropical pasture and forage cultivars have largely been developed by selections among natural variants from phenotypes which appeared superior in forage yield, tiller production, leafiness, color, disease tolerance, persistence, and in some instances favorable response to grazing. Varietal names have been given to some introduced accessions after a period of testing. The success

achieved by CIAT staff in selecting a local biotype of Stylosanthes guyanensis (La Libertad) having tolerance to anthracnose as contrasted to the high disease incidence of most imported cultivars should be noted. A diversity of natural variation exists among most pasture species. This should be thoroughly sampled and the less complex methods of plant improvement (e.g. mass selection) be used before launching a sophisticated breeding program. As the need arises the CIAT staff can then give consideration to the use of more intensive techniques and procedures for development of pasture plant cultivars.

2.2 Seed Production

For improved pastures to become a reality two vital aspects need urgent attention: (1) seed supply of suitable legumes and grasses, and (2) availability of reasonably priced superphosphate.

Lack of seed is a primary limiting factor in tropical pasture development, excepting Australia. Legume and grass seeds are not produced commercially in tropical America. Limited supplies are locally hand-harvested but are of low quality and poor germination so that sowing rates are frequently measured in terms of bags rather than kilograms per hectare. Limited quantities of seed can be imported from Australia and East Africa but these cultivars are not always adapted to other tropical areas due to natural selection, genetic drift, and environmental factors.

The Review Team recognizes the preliminary effort by CIAT staff in the seed increase of locally selected and adapted biotypes of Stylosanthes guyanensis and Paspalum plicatulum and a promising introduction of Urochloa mozanbicensis.

The team members place first priority on seed production and recommends that funds be made available to employ a forage agronomist knowledgeable in seed production and related technology for not less than three and preferably five years. Information is needed about phenology, especially flowering behavior and seed set under different environments, pollinators of legumes, seed physiology, agronomic production practices, harvesting, processing, storing, and marketing. Seed producing activities should be integrated into national programs in cooperation with interested commercial firms.

Development of seed production technology will not assure an immediate massive demand for improved pasture seed, especially in view of the widespread absentee owner type of cattle enterprise in the lowland tropics. Pasture experimentation and field demonstrations, however, are currently severely restricted by lack of seed. Furthermore, such information is vital as a forerunner to the development of a pasture legumes and grass seed industry in tropical America.

2.3 Mineral Nutrition of Legumes and Grasses

CIAT is to be commended on its progressive approach to research on the mineral nutrition of pasture plants. This research, particularly that relating to legumes, should be intensified. In the vast areas of low fertility, acid soils which will be used for pastures and not crops, there is an overriding deficiency of nitrogen coupled with a gross deficiency of phosphorus. Legumes are often the cheapest and most efficient source of nitrogen for the growth of associated pasture grasses and production of protein for grazing cattle.

CIAT's work on the nutrient problems of soils of low pH (around pH 4.5), coupled with a very low calcium content and a high aluminum saturation, is very important because of the extensive areas of these soils in the Latin American tropics. CIAT is now a research leader on the problems of very acid soils high in aluminum which occur in areas such as the Llanos of Colombia and Venezuela, the Cerrado of Brazil, and the Amazonian region. However, there are many unresolved problems associated with very acid soils including reactions of species and genotypes within species to the balance and supply of soil nutrients, maintenance requirements of improved pastures for fertilizers, and the adequacy of minerals in the pasture for the grazing animal. As an example, it was observed that the Stylosanthes species at Carimagua were not growing as vigorously as they should in spite of being supplied with adequate P and Ca. It is apparent that CIAT's important research on the nutrient needs of pastures on very acid soils warrants additional support.

Improved pasture systems require inputs of the essential minerals including N, P, S, Ca, K, Mo, etc. if they are to increase the year round supply of digestible energy, protein, and minerals and significantly raise rates of stocking, calving,

liveweight gain, and consequently beef production per hectare. It will be necessary for CIAT to give particular attention to the mineral status and needs of the improved pasture systems which are developed. Appropriate analysis of the just-mature leaves of legumes in the pasture for important elements like N, P, S, Ca, and K gives an accurate indication of sufficiencies or deficiencies of these elements. Critical values for these elements are available for the main tropical legumes. Soil analyses are often misleading and foliar analyses are a more reliable index of the available soil nutrients. As the CIAT program develops, rapid analytical methods for the key elements, particularly in the legume component of pastures, will become essential for progress. Within a few years it will probably be necessary to appoint a well qualified chemist to cope with the demands for mineral and other analyses generated by the expanded work on improved pasture-animal systems.

Extensive areas of the vital legume-grass pastures will not become a reality in the tropics of Latin America unless and until adequate supplies of superphosphate become available at a reasonable price. CIAT could make a major contribution to improved pasture and cattle production in the lowland tropics by undertaking a survey of the phosphorus situation. Such a survey would involve a great deal of travel and literature review but could be completed within 12 months. The requirement is so urgent that the Review Team suggests that CIAT seriously consider giving high priority to this effort.

A phosphate survey embracing the tropics of Latin America would need to:

(1) Identify the location, extent, and quality of the known rock phosphate deposits in this area.

(2) Give the location and output of factories making superphosphate together with the source of raw materials, comparison of the prices of imported and local rock phosphates, cost of production, demand, selling price, etc.

(3) Suggest sites for new superphosphate works in the different countries relative to projected increases in demand as a consequence of the adoption of improved pasture technology.

(4) Do a cost-benefit analysis for the use of superphosphate in improved pastures, taking into account current and potential prices of superphosphate.

(5) Stimulate interest in use of superphosphate and exploration for further deposits of rock phosphate.

The findings of the survey should be published in booklet form and made widely available. There is little doubt that it would make a significant contribution to the major objectives of CIAT's beef cattle program.

A less intensive survey of lime deposits is indicated as calcium carbonate has proved to be important in the neutralization of aluminum and as a fertilizer in very acid soils. There is little need for CIAT to be directly concerned with the supply of other minerals used in fertilizers. Single superphosphate usually contains 9.6 percent P, 10 percent S, and 20 percent Ca which is an excellent balance of these three essential elements. Double superphosphate with twice the P, but 15 percent Ca and only 1.5 percent S may eventually be used to reduce cost of transport and application of P but this could cause nutrient supply problems. It is possible that Mo will prove to be deficient in many acid soils but it should not be difficult to persuade manufacturers to add this element to superphosphate. In pasture establishment, legume seeds can be pelleted with molybdenum trioxide. If necessary, any minor element found deficient could be sprayed in solution on established pastures.

Potassium fertilizers are readily available on the world market and should not be required regularly nor in large quantities for an improved pasture system. Nitrogenous fertilizers are also readily available but they are often too expensive to use on a wide scale in improved pastures. Pasture legumes usually prove to be a more efficient and much less expensive source of nitrogen and protein for extensive pasture development.

2.4 Soil Microbiology

CIAT's research on the selection of rhizobial strains for the different legumes is of high quality. It has been found elsewhere that the elite strains used for seed

inoculation of a number of legumes often do not compete with the native rhizobia which then establish the symbiotic relationship. There are exceptions as with Leucaena, some Stylosanthes species, and Lotononis where a highly specific rhizobium is required to effect symbiosis and nodulation. However the lack of success in the inoculation of a number of common legumes (Centro, Puero, Siratro, a number of Stylosanthes, Glycine, Desmodium) does pose the question as to whether rhizobial strains which are usually selected in sterile conditions, at pH 6-7 are the right ones. Consideration should be given to selecting rhizobial strains in unsterilized acid soils of around pH 4.5. If such strains were unable to compete with the native ones the production of elite rhizobial strains for inoculation of a number of the common legumes at planting would not seem to be warranted.

CIAT should maintain contact with Dr. J. Dobereiner's research at IPEACS near Rio de Janeiro on the capacity of C_4 grasses to stimulate nitrogen-fixing organisms in their rhizosphere. It is doubtful that CIAT should embark on a program in this field. Most attention should be given to the feasibility of selecting effective elite rhizobial strains which compete with native strains for the main pasture legumes. If successful this could be a significant factor in pasture development on the extensive and very acid soils of the Llanos, Campo Cerrado, and Amazonia. CIAT's work on pelleting legume seed with various substances as an aid to rhizobial inoculation is good and should be intensified as this is important in the establishment of the elite strains in very acid soils. As well as supplying P and Ca in the pellet, Mo should also be considered.

2.5 Pasture Establishment and Maintenance

The replacement of native pasture species with improved types follows a progressive pattern from low to increasing soil fertility with population changes in the various species depending on their adaptation to different nutrient levels.

In the wetter areas with 1,500 mm or more of annual rainfall mixtures of Panicum maximum (Guinea grass), Centrosema (Centro), Pueraria phaseoloides (Puero or Kudzu), and Stylosanthes guyanensis (Stylo) fertilized with about 250 kg/ha of superphosphate would be successful. Pelleting the legume seed with molybdenum trioxide would be advisable as the element Mo is essential in nitrogen

fixation by Rhizobium. On the more acid soils of around pH 4.5 a preliminary application of lime would assure the uptake of P and Ca by pasture legumes. This type of pasture is applicable to many parts of the Brazilian "Campo Cerrado", Amazon and "Chaco" regions, Colombia and Venezuelan Llanos, Bolivian savannahs, Andean valleys, North coastal areas of Colombia, and regions of Central America.

In areas with more intense dry seasons the legume Macroptilium atropurpureum (Siratro) should be included in mixtures with Guinea grass. This species has provided a well balanced pasture on the red sandy acid soils of São Paulo State, with or without Centro, when fertilized with superphosphate.

It is recognized that the use of guinea grass-legume mixtures represent a high level of fertilizer input for establishment and maintenance. However, these species grow over a wide range of conditions in the lowland tropics and with judicious pasture management can provide a year-round source of digestible energy and protein for cattle. CIAT should take the leadership in extending their use for the entrepreneur interested in optimizing animal output.

Melinis minutiflora (Molasses grass) is widely used because of its ease of establishment on low fertility soils and abundant seed production. It is a first step in the progressive improvement of native grazing lands. It has been shown by CIAT and others that stocking rates and livestock gains can be improved during the rainy periods with the use of this species. Addition of a legume and applied superphosphate will extend available pasturage into the dry season. The Paspalum plicatulum-Stylo combination under investigation at the ICA Carimagua Station provides another alternative as pioneer species on very acid soils where annual superphosphate dressings are not always practical and economical. On such pastures the application of about 125 kg/ha of superphosphate at establishment might be feasible. Maintenance fertilizer is as important for continued output of pastures as for establishment.

Other legume-grass combinations are being evaluated by the CIAT staff and additional ones will need to be examined as the Outreach Program extends into other environments. Mention has been made of Leucaena leucocephala and attention should be given to its use in combination with grasses, especially high quality aggressive species which suppress the growth of trailing and bunch-type legumes. Leucaena

is not easy to establish and research is needed on factors such as seed treatment, depth of planting, width between rows, use of lime and superphosphate, weed control, etc. Once established, this legume withstands heavy grazing and a grass such as B. decumbens could be established between the rows. Rotational or periodic grazing of Leucaena maintains its vigor and lessens the possibility of loss of tail and rump hair (due to mimosine content) in cattle.

Hyparrhenia rufa ("jaragua" "puntero") covers vast areas of many tropical American savannahs and rapidly moves into newly cleared lands from nearby stands, or is sown by cattlemen. The grass is highly aggressive and competitive but in many regions native or naturalized legumes appear spontaneously and sporadically. It would be unwise to destroy this grass species in many areas and research should be directed toward means of introducing improved legumes and grasses. This implies methods of pasture establishment and applying superphosphate.

Improved pasture establishment studies initiated by the CIAT staff should be continued and expanded to cover a series of treatments ranging from oversowing native grazing lands to complete soil tillage and seedbed preparation. They might include close grazing and sod scarification with oversowing; accumulation of flammable material for burning and sowing into the ash; strip planting; sod sowing; various degrees of sod disturbance by discing, followed by seeding and rolling; turning of the sod, with harrowing and seeding. Attention should be given to fertilization, seeding rates and legume mixtures, time and depth of sowing, weed control practices, pelleting, etc. Considerable literature exists in regard to these types of practices and should be consulted before finalization of plans.

Weed control is of primary importance in the establishment and maintenance of tropical pastures. There may be need for the use of chemical methods for control of certain species prior to sowing improved pastures (e.g. Paspalum fasciculatum which is being examined by CIAT) and for spot spraying of woody regrowth in established pastures. The widespread use of weedicides such as Tordon should

be viewed critically, however, because of persistence and killing of legumes. The economics of extensive chemical spraying must be given careful consideration and compared with other methods of weed control.

The Review Team recommends that the weed control research be more closely integrated with studies on the establishment of improved pastures and their maintenance with emphasis given to ecological and biological weed control. A vigorous,well managed improved tropical pasture competes strongly with weeds but may be invaded to some extent with woody species. The effect of fire on woody regrowth should be studied with attention given to time and frequency of burn, accumulation of flammable material, changes in botanical composition, effect on regrowth of desirable species and their longevity, and grazing management after burning. This aspect of weed control must be coordinated with the development of pasture management systems as indiscriminant burning leads to degradation of the sward. Considerable data exists regarding burning from African studies and this information should be consulted,as little is known in tropical America on this subject.

The time of grazing after sowing, stocking rates, and grazing intensities strongly influence the establishment and maintenance of pastures. Such information will be obtained from on-going CIAT studies but must be emphasized in the Training and Outreach Programs.

2.6 Evaluation of Nutritive Value of Legumes and Grasses

CIAT's research on the nutritive value of legumes and grasses is good. It is appropriate that the African type of sheep adapted to tropical environments is being used in nutritional evaluations. The assumption that tropical pasture species are always of lower nutritive value than temperate species is not valid. At the early growth stages the better tropical grasses have similar digestibilities and intakes to most temperate grasses with the possible exception of the rye grasses. Tropical legumes like Leucaena have as high a nutritive value as most temperate ones. With the grasses the greatest difference in nutritive value in favor of the temperates is during the later stages of growth when the C_4 tropical grasses build up fibre and

lignin more rapidly. In any case it must be remembered that temperate grasses are usually grown under cooler climatic conditions than tropicals so that their fibre development is slower.

In CIAT's program, attention needs to be given to the digestibility, intake, etc. of the more mature forage as they determine animal performance in the dry season. With improved legume-grass pastures cattle tend to selectively eat young leaves and shoots of grasses early in the growing season but as the season progresses they eat more legumes to balance their diet. Legumes maintain a relatively high digestibility and intake throughout the year and during the latter half of the season help balance out the decreased nutritive value of the maturing grasses. Improved pastures are more drought resistant than the native grasses and their component legumes and grasses produce some green leaf high in digestible energy and protein in the dry season. The green leaf in improved pastures is selectively grazed and this stimulates intake of dry forage as well, so that cattle maintain weight in the dry season. Often unimproved native pastures are only able to maintain reasonable weight gain and productivity in cattle for about 4 months after the start of the main growing season. For the rest of the year the nutritive value of native pastures declines rapidly so that cattle lose weight.

Presently there are two rumen nutritionists at CIAT (one CIAT and one visiting scientist from Wageningen) studying various aspects of the nutritive value of tropical pasture species and forages. Research on ruminant nutrition can help evaluate and direct attention to the factors involved in the better performance of cattle on improved pastures. Greater support must be given to the agronomic work which will make the establishment and maintenance of improved pastures a reality. CIAT's program in these important aspects should be expedited.

In the future CIAT program on the nutritive value of pasture species and forages, attention should be given to the nutritive value of legumes and grasses in the dry season. Work is needed with the drought resistant legume Leucaena which is capable of producing high protein-high quality forage in the dry season.

The use of cattle with oesophageal fistulae would give a realistic measure of what is being eaten (and its quality) throughout the year on both improved and native pastures. The work on the estimation of digestibility, intake, etc. in cages is a very useful basis for the nutritive value of species but should not be expanded. More attention should be given to the assessment of intake and other parameters in the field. Animal performance is the final index of the nutritive value of pasture species. Relatively simple experiments involving 0.5/ha paddocks sown to different species or mixtures can be used to accurately define nutritive value. In these experiments a stocking rate of 5-6 (or more) yearling steers per ha could be used over the main growing season and their rate of weight gain would give directly the nutritive value of the particular species or mixture.

2.7 Cost Evaluations

It is clear that there are many alternative sources of grazing and harvested feeds for livestock in the lowland tropics. Further,there are numerous alternative techniques for producing the various forages. In order to provide relevant decision making or choice guides to producers, it is essential that cost effectiveness analyses be made of the various sources of feed produced in the different ways. Cost effectiveness in this case is defined as the minimum cost to achieve a given objective. This information, along with similar analyses for the livestock sector, provide the basis for choosing the optimum production system and for estimating returns to be expected from the systems.

Cost effective analyses require that the economists constitute a part of the investigative team from the initiation of the work until it is completed. This includes participation in the various steps involved in problem identification, derivation of alternative solutions, and research design. Only in this way can one be assured that the research design will be such as to be amenable to economic analysis.

Obviously,the basic research data must be reported in physical terms so as to permit analysis under changing cost and price relationships. This caution is particularly relevant where, as is true in the case of CIAT, cross country comparisons are important.

3.0 BEEF CATTLE PRODUCTION

The objective of the CIAT beef cattle production program for the lowland tropics is the development and dissemination of technology to improve animal performance by increasing reproductive rates and increasing rate of growth of market animals. These are the basic factors that limit beef production in the lowland tropics. An adequate supply of high quality feed throughout the year is a primary basis for increasing animal performance. Thus, the basic orientation of the CIAT beef cattle program should be the soil-plant-animal continuum. Since the target areas for increasing beef cattle production in the lowland tropics are reproduction rate and growth rate, the program orientation must be specific toward gaining solutions to the major problems that affect them. These are problems that relate to nutrition, animal health, reproduction, breeding and management systems.

The basic approach of CIAT involving integration of disciplines that pertain to a given segment of the technological continuum and with integration among the segments of the soil-plant-animal continuum is commendable and should provide the highest probability of success for achieving goals and objectives. It is difficult to over emphasize the importance of the problem solving approach to research planning and the mission orientation to research execution in the present era of the CIAT beef cattle program. The generation and dissemination of relevant technology that may be implemented to result in increased reproduction rate by decreasing age at first calving and reducing calving interval; improved health status to result in reduced animal mortality, a decrease in reproductive problems and increased weight gains; and increased rate of gain to result in reduced age at slaughter weight and increased gross efficiency is a goal that will continuously challenge the highest level of imagination and will require total commitment.

Since increased reproductive rate and increased growth rate are the primary "payoff" units of the CIAT beef program, the effectiveness of all beef program com-

ponents should be evaluated on the basis of their contributions to improvements in one or more of them. It is recognized that a series of steps may be involved in the problem-solution chain leading to a "payoff" unit.

3.1 Nutrition

The basic objectives of the nutrition component of the CIAT beef program should be to develop feeding systems to increase reproduction rate, increase rate and economy of gain, and to minimize the effects of stress associated with diseases and parasites. It is strongly recommended that the perspective for the CIAT beef program continue to be oriented through the soil with a strong improved pasture dimension as a basis for improving nutritional status on a year-round basis.

The existing vegetation in the lowland tropics alone, will support neither a high level of animal performance nor a high level of production per unit of land resource. The basis for increased production and improved productive efficiency is more adequate nutritive levels through the introduction and fertilization of improved plant species (legumes and grasses) and/or through supplemental feeding. More land in native pasture cannot be considered an alternative to establishing improved pastures. Native pastures alone will not provide the protein, energy, and minerals required for adequate performance levels. Special emphasis should be given to the establishment of improved pastures which will supply adequate feed during dry periods, as is recommended in the section on Feed Production of this report.

However, it is recommended that modest attention be given to improving utilization of native pastures. Native pastures will continue to occupy a high percentage of land resources of the lowland tropics for a considerable period. Thus, new technology that relates to increasing their value is of importance. Feed supplements (protein, energy and minerals) should be given attention including use of

conserved forage crops as supplements. Nonprotein nitrogen (NPN) as a basis for providing supplementary protein should continue to be considered in the CIAT program, using locally available energy source carriers. This could involve both reproducing and growing-finishing animals.

Work on mineral nutrition should be directed largely to the evaluation of the available information in comparative experiments carried out in different areas of the lowland tropics as a complement to management of native and improved pastures.

CIAT efforts on beef cattle nutrition should include the evaluation of factors that affect nutritive value of different legume and grass species. This type of information is essential for developing procedures for improving forage quality and for the development of economically feasible programs of feed supplementation to both improved and native pastures during periods of inadequate nutrient availability. These efforts should relate to basic principles involving general considerations of the lowland tropics, rather than to specific situations, and should be integrated with pasture and forage production interests.

3.2 Animal Health

The CIAT animal health program has the potential for having a major impact on beef production in the lowland tropics through the development of technology as well as the training, attitudes and leadership that it can influence. The animal health program of CIAT appears to be planned with the flexibility necessary to adjust to changing situations. Close collaboration with national animal health programs is essential for maximum impact. Strong leadership of the CIAT animal health staff will be required for effective implementation of adequate animal health programs for major increases in beef production in the lowland tropics. This program can be expected to contribute effectively to CIAT outreach objectives through technical assistance and training at an early date.

Diseases and parasites in the lowland tropics represent a major constraint to efficient beef cattle production programs. Epidemiological studies are one area of major emphasis in the CIAT animal health program. The surveillance of diseases and parasites which occur in the lowland tropics is an important component of this program. The importance of epidemiology as a control tool suggests increased training opportunities for animal health officers in surveillance and sample survey techniques. Such training must demonstrate quantitatively, and in socioeconomic terms, the losses which can be expected if adequate control measures are not provided.

In solving disease problems which affect productivity, sound and practical laboratory and epidemiological approaches should be available to national programs. A survey should be conducted to determine the present status of animal health centers in the lowland tropics in regard to programs, plans, etc., as a basis for determining the opportunities for CIAT in transferring new technology, providing training, etc. Information available (V Interamerican Meeting on Foot and Mouth Disease, Mexico, 1972) indicates that several countries are establishing laboratories for diagnosis and research purposes. However, there is a marked shortage in trained laboratory personnel in the areas of blood parasites, reproductive diseases and toxic diseases. In addition, the Latin American countries lack a reference laboratory in exotic diseases. The CIAT animal health program should explore ways that it can complement and supplement national programs involving training, laboratory service and advisory technical assistance. The recommended survey would provide information that would be useful in planning and organizing these efforts.

Major emphasis of the CIAT animal health program should be on reproductive diseases, blood parasite diseases, and preventive medicine programs for the newly opened lands of the lowland tropics. Many new areas are being committed to cattle production in the Amazon region, Campo Cerrado of Brazil, the Llanos of Colombia

and Venezuela and other similar areas of Ecuador, Peru, Bolivia and Central America. Attention should be given to developing adequate procedures for the prevention of the spread of diseases into these areas that have had a low density cattle population.

It is recommended that the present emphasis on monitoring reproductive disease incidence be continued only to long as is necessary to adequately clarify the situation. If present results are confirmed showing reproductive diseases to be relatively unimportant causative factors of low reproduction, the level of emphasis in this area should be reduced. Obviously, some activity on the monitoring of reproductive diseases should be on a continuing basis for training purposes in outreach programs.

The hemoparasitic disease projects should be oriented to solving problems which affect beef cattle production in the lowland tropics, through training and in cooperative projects with national programs. Blood parasite diseases occur in all the tropical regions and very little is known about their importance and/or possible control measures. The impact of the CIAT animal health program may be appreciably increased by assuming a major coordinating role with national programs in the broad area of hemoparasitic diseases.

It is recommended that the collaborative program with Texas A&M University on hemoparasites be closely coordinated with the CIAT animal health program. The CIAT programs should provide the basis for problem identification for the collaborative staff involved in training programs in this area at Texas A&M University.

An entomologist is needed in the hemoparasite program who will give primary attention to tick ecology, and it is understood that attention is being given to this staff addition.

Research on foot and mouth disease, which is considered to be the most significant infectious disease of cattle in the lowland tropics, is being done at the Panamerican Foot

and Mouth Disease Center in Rio de Janeiro. The area of influence of the Center is extensive over the Americas. Comprehensive research and service programs are underway there, thus, CIAT should consider only limited work on field evaluations in coordination with the Center.

Vesicular stomatitis is endemic in most tropical countries, except Brazil, and very little is known about this disease, which is similar to foot and mouth disease. When adequate isolation facilities are available for animal experimentation, perhaps some attention should be given to this disease at CIAT. Epidemiological and control studies on vesicular stomatitis may serve as a model for controlling foot and mouth disease.

It is recommended that CIAT undertake studies which will determine the relationship between nutritional status and disease. Surveillance of diseases should include information on the diets which are available for the animals being tested for disease considerations. In the same manner, attention should be given to specific diseases arising from nutrient deficiencies and toxic soils or plants which may occur in the lowland tropics.

In the area of exotic diseases, which are a hazard to cattle in the lowland tropics, the animal health program staff should be able to assist national programs in providing some nonliving reagents and reference information on laboratories which can help and measures to be taken in case of a new disease entering a country. Safe isolation units may be needed at Palmira to permit work with pathogens in animals (viruses and bacterials). Present facilities are limiting in this regard.

3.3. Reproduction

Marked improvements in reproduction rate must be accomplished to permit an economically viable beef industry in the tropics. This must include both a reduction in age at first calving and decreased calving intervals. It is believed that improved nutrition through an improved pasture program should provide the basis

for improvement in reproduction rate. Present information suggests that reproductive diseases are probably not a major causative factor for the low reproduction rate. Nutrient supplementation (protein, energy, and minerals) to both improved and native pastures at critical periods during the reproduction cycle and synchronized with plant nutritive values should continue to be explored. Early weaning might be considered as a management system for situations where the feed environment may be particularly limiting for reproduction.

It is recommended that CIAT consider adding a senior staff member trained and experienced as a reproduction specialist at the production level. This should be a competent scientist who has a good understanding of the nutrition, disease, physiological, genetic, and other factors that influence reproduction rate. His charge should be to assist in coordinating the research in the different areas that relate to improving reproduction rate and to help keep total efforts oriented specifically to this basic target.

While breeding research, as such, should receive a relatively low level of emphasis in the CIAT beef program, it is recommended that CIAT be in a position to provide technical assistance of an advisory or consultative nature to national beef cattle breeding programs. Principles that have been developed in other tropical and in temperate areas are relevant and should be generally applicable to the lowland tropics. Thus, programs should be implemented taking full cognizance of this technological base. This might be regarded as an important dimension of an outreach program.

Even though the basic factors may not favor a high level of emphasis to breeding research in the CIAT beef program, this area should not be ignored. The breeding component of integrated, multidiscipline programs should be considered simultaneously with the nutrition, reproduction and animal health components in the development of management systems to maximize returns to basic resources. A basic consideration

involving the breeding component of the CIAT beef program is the synchronization of the germ plasm capability (performance level) to the climatic, feed and animal health environments of the lowland tropics, i.e. cattle that are well adapted to major components of the environment. Existing technology is relevant and should be used.

Bos taurus and Bos indicus populations of cattle that are well adapted to the climatic environment and with perhaps relatively superior adaptability to the animal health and feed environments of the lowland tropics are available and should provide the germ plasm base for the breeding component of CIAT beef program efforts. Programs are indicated to maximize the rate of genetic improvement in seedstock herds of these populations, and commercial production programs to utilize heterosis through either organized crossbreeding systems or the development of multibreed synthetics using these stocks.

3.4 Herd Management Systems

It is recommended that the CIAT beef program provide leadership to national programs for the development of managerial skills involving both technological and fiscal management considerations for both owner-operator and absentee owner situations. Effective managers at the production level are essential to the development of a viable beef cattle industry in the lowland tropics. It is clear that this is indeed a complex matter in Latin America, but it must be recognized as a major constraint in developing an efficient beef cattle industry.

Research should continue to determine the different managerial aspects which influence cattle productivity in the lowland tropics. These should relate to more effective utilization of the basic resources and may include studies on influence of seasonal breeding, management of native and improved pastures, early weaning, rotational versus continuous grazing, animal health practices, etc. In addition, adequate record keeping systems and economic evaluations are required at the farm level for making the most accurate managerial decisions.

It is recognized that CIAT is making progress toward the development of technological packages that can be implemented to maximize the yield on biologically related resources. In developing these packages, a high level of coordination is required among the different biologically related components of these packages and the synchronization of the technological packages with the managerial situation. A primary objective of these efforts should be to increase managerial effectiveness at the production level. The value of new technology is a function of managerial effectiveness at the site of implementation.

3.5 Economic Evaluations

The same comments made regarding cost effectiveness studies as related to feed production apply in full measure to research relating to livestock production. However, evaluation of alternative animal health strategies presents a particularly challenging dimension and is a problem which has been largely ignored by economists. It is known that there are several animal disease hazards of great economic consequence in the lowland tropics. Further, there exists alternative strategies for dealing with the hazards and research will provide additional avenues of approach. What is needed is a workable approach to providing cost-benefit analyses of alternative strategies. The Baysian approach would appear to offer a promising framework for solving the problem since it is obvious that the outcome of the various strategies is uncertain and the probability of various outcomes is not known, although some estimates of outcomes can be made. Obviously, externalities cannot be ignored in evaluating the alternative animal health strategies. That is, the outcome of a given treatment on a given production unit depends to some degree on the practices followed on neighboring production units.

One obvious application of cost-benefit analysis of alternative animal health strategies would be to evaluated the relevance, in terms of potential payoff rates, of research projects aimed at producing new approaches to health hazards. That is,

given the economic loss attributable to a given health hazard and cost of research to provide a new approach, one could estimate the rate of return to the research, if it were successful. The same basic considerations are appropriate for other components of an integrated beef cattle program. However, caution is indicated in interpreting an analysis of a single component when there are interrelationships or interactions among the components as is the case among the biological components of beef production.

4.0 PRODUCTION SYSTEMS

4.1 Existing Production Systems

Clearly a knowledge of existing production techniques, systems and results is an important prerequisite to the maintenance of research and training programs properly oriented to the needs of the clientele to be served. In some countries, as a consequence of the backgrounds of the researchers and teachers and the interaction of professionals in research and teaching with producers in the fields, current information of this type is readily available. However, in Latin America where few professional agriculturalists have rural backgrounds or day-to-day contact with the various production strata, there is a serious lack of such information. This void can constitute a serious impediment to the identification of relevant research and training objectives.

CIAT is to be commended for two major efforts directed to the development of a better understanding of production systems and problems of livestock producers in Colombia. The first of these was a survey of 487 livestock producers in the North Coast area of Colombia. 6/ The second such effort is a current team survey of small cattle ranches in the Colombian Llanos which is being done in cooperation with the Fondo Ganadero del Meta. This survey will provide accurate estimates of calving rates, death losses, health status, and production levels. In addition, physiological and health data are being taken along with soil and pasture samples.

The team recommends that, as resources permit, status surveys of other major areas be made, and that changes in production techniques and systems be monitored. Special attention should be devoted to monitoring the results of newly adopted techniques and systems, such as new and improved legumes and grasses, as well as systems in-

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6/ Libardo Rivas Rios. 1973. Aspectos de la ganadería vacuna en las llanuras del Caribe en Colombia. Centro Internacional de Agricultura Tropical. Cali, Colombia.

volving pasture fertilization. Another system which requires monitoring is the type which involves various cultivated crop-pasture rotations. An example is the planting of pasture following rice.

4.2 Input and Product Markets

Preliminary observations suggest that poor markets for production inputs and for the final product, beef, exert a serious drag on the development of the livestock industry in the lowland tropics. Several including the World Bank co-operating with national institutions, have increased the flow of capital investment funds to the cattle industry. Much less appears to have been done to improve the flow of improved seeds, fertilizers, and technical information to producers.

Although several new slaughter plants have been built in the lowland tropics, the team is aware of no comprehensive analyses of the structure, nor of the technical or economic efficiency of the beef marketing system of the area. In any event, current market structures and facilities are unlikely to be adequate for the potential increase in supply. Analyses of beef input and product markets in the various countries would logically appear to be the responsibility of the various national institutions. However, there would appear to be an opportunity for outreach on the part of CIAT in the form of technical support and coordination.

There is now a general consensus that both internal and export markets for beef will expand rapidly in the decades ahead. Yet it is important that export opportunities be carefully analyzed and monitored. Particular attention should be devoted to analyses of factors affecting the competitive position of areas of the lowland tropics with other producing areas in world markets. In view of the importance of export markets to the orderly development of the livestock industry of the lowland tropics, this activity might logically be considered to be an appropriate responsibility for CIAT.

4.3 Producer Investment Decisions

In the final analysis, the future of the lowland tropics beef industry is dependent on the investment decisions of current and potential beef producers. Research and

Training can enhance the potential for industry growth. However, movement toward the economic production potential requires producer investments in cattle and in technology in the form of pasture improvements, animal health, and herd management.

In light of the essential role of producer decision making, the team recommends that CIAT undertake a pilot study of the factors relating to investment decisions of current and prospective producers. This study should include an analysis of a cross section of producers and potential producers, as well as analyses of secondary data. Such studies could be of assistance to CIAT in establishing research priorities. They could also be valuable to public policy makers in establishing policies to achieve defined objectives with respect to the cattle industry in the various countries. There would appear to be a probability of non-core financing in support of research in this area.

In making supply-response estimates in the tropics, special attention should be given to decision processes on units with absentee owners. It is generally thought that these units represent a major share of beef production in the lowland tropics. It is quite likely that relevant supply response factors on absentee owner units may be quite different from those on owner operation units. Thus, it may develop that different educational, policy and market variables might need to be employed to bring about response on the different tenure situation.

4.4 Food and Cash Crop Alternatives

Soils of the humid lowland tropics are generally very acid and infertile. These conditions are readily modified for satisfactory crop growth by liming and heavy applications of fertilizers. Nonetheless, very little lime and fertilizer are used and agricultural production on such soils is very limited because of several cultural, social, and economic factors. The cost of inputs are likely to remain high in price until appropriate infrastructures are developed (roads, fertilizer factories in the country, markets, etc.).

One approach to this problem of low soil productivity, in the absence of substantial applications of fertilizer and lime, is the selection of species which are better adapted to the native soil environment and which require a minimum of high cost inputs. [7/] Many tropical species are well adapted to extremely acid soil conditions and are often also very efficient in absorbing native soil phosphorus. Mango, citrus, and cashew are among the more acid-tolerant fruit and nut crops. Tropical farmers have made use of cassava and tropical yams as food crops for centuries both for subsistence and commercial products.

In recent years,a number of annuals, including cereals and legumes, have been shown to vary markedly between varieties and cultivars in regard to acid soil tolerance. Upland rice is one of these examples. Traditional varieties such as Mono-Olaya, planted extensively in Eastern Colombia, barely respond to the first increment of lime and produce up to 3 tons of grain/ha with no lime added, while many of the new semi-dwarf varieties respond strikingly to lime and produce practically nothing in its absence under upland conditions.

Among the grain legumes, cowpeas and peanuts are the most tolerant to acidity. Black beans are intermediate in tolerance to acidity while the non-black beans are the poorest. Other crops that have been observed in tropical areas with little or no fertilizers are sugar cane and sesame. Some varieties of corn are also moderately tolerant to soil acidity.

A great part of the area of the lowland tropics is not covered with forest. It is a natural savannah or cerrado where wood is very scarce. Introduction of forest species could be desirable as a cash crop, for posts and building materials, and as fuel. The Review Team recommends that the experiments conducted with tropically adapted species of crops should continue, in cooperation with the crops program.

7/ J.M. Spain and Rodriguez, M. 1972. Differential species and varietal responses to Phosphorus and Lime on a Colombian oxisol. Paper presented at the American Society of Agronomy meetings. October 30, 1972.

4.5 Farm - Ranch Structures

The CIAT work on farm structures, including windmills, water tanks, and low cost housing appears to be needed. Thus, the team recommends the continuation of this work as needs and resources justify.

4.6 The Development of Soil-Pasture-Animal Systems

The main problem in the principal areas of native grasses used for grazing cattle is a deficiency of digestible energy, protein, and minerals for many months of the year. As has been pointed out previously, this results in low rates of calving and weight gain, a slaughter age of 4 to 5 years, and a low production of beef per hectare. The research work on tropical pasture improvement done by CIAT and other organizations has already been outlined in this report. To capitalize on the knowledge and technology presently available it is necessary to fit it into a suitable system which will result in increased beef production and monetary returns on ranches.

It is acknowledged that native pastures will occupy a high proportion of the area of ranches for some time and that the introduction of improved pastures by a motivated owner will be a progressive but relatively slow process. Thus a system is required which will make the best use of both native and improved pasture so that more digestible nutrients are available to the grazing animal during the year. Productive energy yield per unit area determines the output of animal products from a pasture and the financial return to the farmer.

It should be emphasized that monetary returns depend on how well the grazing animal utilizes whatever pasture system is developed. Thus, attention must be given to using a good responsive line of cattle. The line of animal used should be constantly upgraded by mass selection for the important parameters such as calving rate, rate of weight gain, etc.

In order to get a better return in meat and calves from native pasture there must be some inputs and better management practices. A suitable mixture containing salt

and the essential minerals should be constantly available in troughs with a roof. More intensive grazing of about a third of a native pasture area during the main growing season will keep the native pasture short and give the best possible supply of digestible nutrients with better results from the animals. After the main growing season the animals could be shifted to the rested native pasture which will be a mass of standing fibrous material of low digestibility. This could then be utilized by the animal with good results through the supply of urea-molasses in drum lickers or suitable blocks containing non-protein nitrogen and a palatable energy source. With this technique animals usually maintain weight in the dry season. Also reproductive rate is maintained at a higher level. These approaches in other countries have lead to a higher level of meat production from native pasture.

The objective, as discussed previously in this report, is to progressively upgrade increasing areas of the native pasture by the introduction of improved legumes and grasses.

The native and improved pasture areas will need to be integrated into a well managed system so that the best overall results are achieved. The improved pasture should not be overgrazed but must be kept grazed to maintain the legume-grass balance. It could be used for finishing steers raised on the native pasture areas and for breeding cows during mating to increase reproductive rates.

Where possible it is suggested that special test areas of the tree legume Leucaena be established. It is not easy to establish, but once established is very resistant to grazing. The Leucaena area could be lightly grazed in the main growing season and then used as a high protein bank in the dry season to supplement other native or improved pasture. Its high protein content and quality will stimulate ruminal activity and lead to the utilization of fibrous pasture material in nearby paddocks to which the animals have access.

The Review Team was impressed with the conception and possibilities of the large collaborative CIAT-ICA Herd Systems Project at Carimagua designed to measure

the response of the cow-calf combination to different methods of utilization of the native pasture. Particular attention was given to this project in view of its importance and scope and the funds and support involved. The Review Team considers that the main objective of this project, which is to find how to improve reproductive performance, may be difficult to achieve because of the large number of variables. It is suggested that the project be changed as follows:

1. Consider elimination of the breed comparisons, which could be done under standard conditions elsewhere, and concentrate on a good Zebu type.

2. Ensure standardization of the burning treatments. Regular and frequent burning may eventually result in degradation of the native pasture.

3. Introduce an improved pasture treatment by discing and seeding into the native pasture a mixture such as Paspalum plicatulum, La Libertad Stylo, and Centrosema pubescens and give an annual fertilizer application of single superphosphate. Rolling after seeding would assist establishment.

Some detail has been given because of the possibilities inherent in this important project. Attention should be given to the use of a standard mineral supplement containing salt, phosphorus, calcium and other minerals, as comparison of mineral treatments may not be a productive line of research when protein is grossly deficient. However, a treatment involving the use of urea-molasses or a block containing non-protein nitrogen, minerals, and a palatable locally available energy source in place of a mineral treatment is suggested. Attention will also need to be given to stocking rate and it is assumed that a suitable stocking rate has been decided. After the improved pasture treatment has been well established it could be given a higher stocking rate. It could be an advantage to divide the calf crop after weaning into two groups and follow their performance on native pasture and improved pasture respectively.

4.7 Economic Implications

The cost effectiveness analysis outlined under the feed and beef production sections provide the basis for analyses leading to the development of optimum production systems, involving the whole farm and ranch organizations, given producer resource situations and maximization objectives. These analyses should adequately consider risk and uncertainity, and should be tested for sensitivity to changes in price and production parameters. Special attention should be devoted to the development of feasible systems for small farm units. For application in countries with high unemployment rates, employment and incomes which might be generated under the different techniques of production and production systems should be considered. Again, considerations must be given to evaluation of alternative systems under various major tenure arrangements. The various programming and simulation techniques appear to offer a feasible and cost effective method of analyzing alternative systems, if computers are available.

It should be clear that the production systems analyses can be utilized to evaluate various farm management plans. However, the production systems analyses should be structured so as to provide insights useful to CIAT in structuring its research programs and to policy makers in the various countries. One application of the production systems analyses would be to determine the constraining technical or economic parameters in the various systems as a means of identifying high priority research needs. For example, if increased production of a forage crop during a particular season would result in a large response in terms of economic returns, one might infer that work leading to the development of a better forage for that season might make an excellent return on the investment.

The systems analyses should provide useful guides to policymakers and program administrators in making judgments regarding the size of unit necessary to be economically viable or in determining capital or other inputs required by the various producing units. Such analyses might also be suggestive of the production

rates required to achieve specific goals. In order to evaluate the competitive position of various systems, estimates of the cost of production per kilo of beef should be made.

Preliminary analyses by CIAT economists suggest that increases in national beef production would tend to generate some improvement in the diets of the poor. However this impact might be relatively minor. Thus,if increased beef production is to have a major positive impact in terms of improving the lot of the poor in the affected countries, it must be felt largely through direct or indirect job creation and resulting income generation. Thus as a part of its economic analysis efforts, CIAT should generate estimates, perhaps in cooperation with one or more national research agencies, of the overall impact of increased beef production on employment and incomes. Further estimates should be made of how the gains might be distributed among the various economic strata. It would also be enlightening to determine how various credit, education, and tenure policies might affect the growth of the industry and the distribution of benefits. National input — output models might provide some initial insights in these areas.

5.0 TRAINING

Currently CIAT has two major training programs. The first, referred to as production training, is for professionals working directly with farmers. The program involves about one year with approximately three months at research stations, primarily CIAT at Palmira, and about eight months of applied experience on a ranch. The on-ranch experience is supervised by CIAT staff. The second major program is the postgraduate intern program and is primarily for professionals involved in research. In this program the trainees act as research assistants for senior CIAT researchers. Depending upon the program, the duration of this training varies from 6-12 months.

In addition to these two major programs, CIAT has a graduate training program which permits individuals who have completed graduate course work to do their research at CIAT. Also there are the special training programs with a duration of 5-6 months, and the workshops which are usually of 2-3 weeks duration. In the section which follows,review team recommendations for the various training programs are presented.

In evaluating CIAT training programs it should be clear that the primary role of CIAT is to train the trainers. That is, the people trained at CIAT are expected to return to their positions and to provide similar training to their colleagues or associates.

5.1 Production Training

It is recognized that a production training program is needed in Latin America as graduates in veterinary medicine, animal science, and agronomy have had little or no practical experience in farming or animal production. Attention needs to be given by CIAT to the selection of trainees who are already employed by a recognized organization. There should be an understanding with their employer that the CIAT training is at a professional level and warrants a suitable increase in salary and responsibility when the trainee returns to his own organization.

The Review Team recommends that the present production training program be re-evaluated. It should be upgraded to ensure that the trainee has had an opportunity to become familiar with the factors involved in pasture establishment, management, and animal production. Also he should become knowledgeable on the major animal health and cattle management problems which he is likely to encounter in the field. Pasture species, fertilization, and management practices are already available for most areas. Thus the Review Team considers that every trainee should be required to participate in the establishment of an improved pasture on a collaborative farm. This is a very important means of extending CIAT's knowledge on improving the feed supply for cattle.

The initial time spent with senior research staff could be at any one of the main research centers, including Palmira, and should be extended to a minimum of 4 months. During this time the trainee would receive academic and field experience in pasture establishment as well as cattle production and management which would be valuable background for his period on the farm. The time spent on the farm should be reduced to no more than 6 months so that the trainee would periodically return to the main research center to which he is attached so that he could receive specific guidance on the problems encountered on the farm. The Review Team is convinced that a more equal balance in the time spent on the farm and research centers would give the trainee a more intensive and valuable training. It is emphasized that the suggested change would only be an advantage if the time spent at the research centers is involved mainly in practical work in association with senior scientists.

As an alternative to the above, considerations could be given to a number of the trainees spending a major portion of their time participating in a prototype production unit at Carimagua involving crops, pastures, and livestock. This would be of considerable value to CIAT's program on production systems for the smaller family farm operation and would appear to offer a superb training opportunity.

5.2 Postgraduate Training

The Review Team agrees that this aspect of training be continued at its present level as support for the CIAT research staff and at the same time to provide an

opportunity for selected trainees to broaden their horizons in the specific areas of interest. Consideration might be given to changing the nomenclature of this type of trainee, perhaps to that of Research Intern, so as not to confuse it with the graduate degree and post-doctoral programs.

5.3 Graduate Degree Training

The Beef Cattle Program is to be commended for the recognition of a valuable CIAT contribution in the area of research training and experience for graduate students. Several graduate students have taken courses at a given university and carried out their dissertational research at CIAT with inputs by both CIAT and university staff members. Several have taken academic courses at the ICA Graduate School with research conducted under the supervision of CIAT staff. The Review Team feels that this aspect of training should be expanded as additional funding becomes available and staff time permits. Latin American graduate students can be a valuable asset to the CIAT outreach program after receiving degrees and returning to their respective home positions.

5.4 Specialized Training

The team was informed that specialized training courses are being planned and the team supports this move. CIAT should establish specialized training courses in specific areas which are of immediate use. It is suggested that a training course on hemoparasitic diseases for laboratory and field personnel be established in countries in which those diseases are widespread. Other areas of interest are production of pasture seeds and establishment of pastures.

5.5 Workshops

There is a major training opportunity in the form of workshops of two to three weeks duration for those involved in advising beef producers, administering programs related to the beef industry, and those providing technical assistance to the beef industry. Such workshops would be comprehensive in coverage and should cover relevant subject matter in considerable depth. The workshops should be structured so that consideration would be given to the soil-feed-livestock-management complex. Emphasis would be in terms of livestock production systems.

6.0 OUTREACH

As an International institution, CIAT must emphasize outreach to countries in the lowland tropics. To date CIAT has engaged in several forms of outreach. For example, the various training programs have involved participants from numerous countries. Also, various CIAT staff members have made contacts with colleagues in many countries and have provided technical advisory services on many research and education projects. More recently two CIAT staff members have been assigned to Guatemala on a special project basis. Indeed, the close working relationship with ICA at Turipana and Carimagua could be considered as outreach activities.

Despite the considerable outreach of CIAT to date, the Review Team is of the opinion that additional outreach of the beef program should receive high priority in the very near future. We specifically recommend that a CIAT research outreach be established at some appropriate place in the Campo Cerrado area of Brazil. This outreach would serve to verify and extend the work being done at Carimagua and could provide useful insights relative to the transferability of the Carimagua results.

CIAT could obtain outreach land and facilities through control by purchase or gift by some country, by cooperation with a national research agency, such as the current program with ICA in Colombia, or by cooperation with private ranchers. The mode of outreach chosen should be determined on the basis of results of a staff study of alternatives including, but not limited to, an estimate of costs.

6.1 Transferability of Research

It is the opinion of the Review Team that the present CIAT Beef Cattle Research staff is fully committed with current programs. In fact, the staff appears to be over-extended in some areas. If CIAT is to extend its programs into other countries it will require additional funds and staff.

There is a distinct need for the Beef Cattle staff to review the results obtained to date and combine them with the information available at other research centers and in the literature both within and outside Latin America. This is essential as a base for the development of a progressive outreach program. The information assembled

may be transferable to most ecological zones in Latin America, e.g., Campo Cerrado, littoral plains of the South American northern coastal plain, and Central America, and should have application to the Amazon region. Differences in soils and climates will necessitate adaptive research with respect to plant nutrition and maintenance fertilizer, pasture establishment and management, and animal production systems. It is fortunate that the main pasture legumes and grasses appear to have a very broad adaptation throughout the lowland tropics of Latin America.

6.2 Priority of Locations

In view of the transferability of the research results from the Llanos to the very extensive areas of very acid soils in the lowland tropics of Latin American and the major collaborative effort with ICA at Carimagua, the Review Team considers that CIAT's first priority with respect to resources must continue to be directed to the work at Carimagua. Of equal priority is the immediate development of a substantial outreach program in the Campo Cerrado of Brazil at a site to be decided by a survey.

It is realized, of course, that for this outreach program funds will be required which will be sufficient to locate no less than two senior staff members with supporting staff and facilities at the site selected. Such an outreach program should be in a region of the Campo Cerrado where there is already a high cattle population, e.g., State of Goias. This would allow the results obtained at Carimagua to have a more immediate impact on cattle production. The latosols of the Llanos and the Campo Cerrado have a similar pH and nutrient status, but due to some inherent chemical differences, CIAT will have the opportunity to add to their original research results obtained in the Llanos.

The proposed research with improved pastures, crops, and production systems, will also add to the research which has been done and is in progress in the Campo Cerrado by other organizations. An outreach program in the Campo Cerrado will add greatly to CIAT's expertise, leadership, and ability to assist in the development of cattle and crop productivity in the extensive and very acid soil areas of the lowland tropics. As a natural consequence CIAT should plan for a further outreach program

at a later date, in the Amazonian region, possibly in collaboration with the newly formed EMBRAPA of Brazil or IVITA of Peru. CIAT will not be able to neglect for very long the challenge of the vast Amazonian region which spans a number of South American countries and in which substantial development is now taking place.

The collaborative ICA-CIAT pasture and beef cattle work on the north coast of Colombia should be continued. However, the work needs to be given a different emphasis and should be done mainly through CIAT's training program. The objective would be to establish improved pastures without delay in the area using the main adapted legumes like Centro, Stylo and Leucaena and grasses like Guinea grass and Paspalum plicatulum together with suitable superphosphate applications. Such a program would not only give the trainees valuable experience, but would provide essential results for both ICA and CIAT. Pasture research results at Turipana must be interpreted with care. This is because fertile, level land, like that on the Turipana station, is more likely to be devoted to crop rather than cattle production.

It is apparent that a major Animal Health program by CIAT-Texas A&M-ICA will be required in this area, typified by the north coast of Colombia, for a long time and will have an impact over a wide area. The emphasis given to hemoparasites should be continued.

Palmira should not be given a high priority for improved pasture and beef cattle research. It will, of course, always be used as the main laboratory center for the senior staff and for the work on digestibility and intake with feeding crates and for analysis of pasture materials. In addition it could be considered as an important field center for the training program.

7.0 IMPLICATIONS FOR STAFFING

An excellent group of beef cattle research scientists has now been assembled in CIAT. The Review Team considers that at this stage careful attention needs to be given to coordinating and integrating activities. For example, collaboration between plant and animal scientists is essential to ensure the establishment and development of improved pasture treatments in the various experiments. Also, coordination between the CIAT Beef and Crop Programs should be strenghtened.

The Review Team is of the opinion that the Beef Cattle Research Group must be expanded without delay if it is to make a real and increasing impact on cattle production in the lowland tropics of Latin America. It is therefore proposed that additional staff is needed in the order of priority given in the following sections.

7.1 Forage Agronomist (Seed Production)

The Review Team places the highest staffing priority on the employment of a Forage Agronomist who would assume major responsibility in developing a research program for production of adapted legume and grass seeds. He would also need to give attention to related areas of seed technology as well as the integration of seed production, processing, storing, and distribution with national seed production agencies and commercial seed producers. His efforts should be coordinated with the present staff in research related to pasture establishment techniques. The team wishes to emphasize the latter point as being essential to integrate the components which are needed to ensure good pasture establishment not only in research trials but also for the development of practices for use by trainees on collaborating farms and for outreach programs.

7.2 Outreach Staffing

The Review Team considers that top priority (equal to the Forage Agronomist) be given to the staffing of an Outreach Program to be located at a suitable site(s) in the Campo Cerrado of Brazil. It is suggested that two Senior Scientists are needed: (1) a Forage Agronomist to work in the area of improved pasture establishment and management and (2) an Animal Scientist to work in the extension of research re-

lated to Animal Production Systems. Complementary Staff and Technical Assistants would of course be required. It should be stressed that the Outreach Program is a Team effort so that there should be close coordination between and among the Staff based at the Palmira Center and the Outreach Staff, with periodic visits in both directions for consultations and reviews of the integrated soil-plant-animal programs.

At some later date additional outreach programs might be located in the Amazon and in other regions as previously indicated.

7.3 Reproduction Specialist

As noted previously, a Reproduction Specialist, with knowledge of animal management, is now needed. It would be expected that he would collaborate closely with the ICA staff at Carimagua. This appointment could materially reinforce the work at that important station.

7.4 Entomologist (Animal Health)

The Review Team was informed that consideration has already been given to the employment of an Entomologist to be attached to the Animal Health unit and firmly endorses this as a critical need.

7.5 Chemist

A Ph. D. Chemist will be required in a few years' time to ensure that the samples from the pasture improvement and animal production programs are analized by the most efficient available methods. He would also be involved in the development of new methods and approaches to the analyses of samples and would collaborate directly in some experiments, particularly those concerned with plant nutrition. The Chemist would also be needed to help in the interpretation of the interactions revealed by the analytical results.

8.0 SUMMARY

The Beef Cattle Review Team was invited to review the CIAT Beef Cattle Research and Training program and to make recommendations relative to programs, staffing, and location of work. The review, which was conducted during May of 1973, can be viewed as part of a continuing planning process on the part of CIAT. This report follows the initial 1966 report by Drs. Roberts and Hardin which provided the basic rationale for CIAT and which was followed by a New York conference. Later, a comprehensive staff report was prepared and Livestock, Pastures and Forages Review Reports were rendered in 1968.

The review initially involved an intensive learning experience on the part of the Review Team. The CIAT staff provided the team with extensive background reading including the 1968 Livestock Review Report, the Pastures and Forages Report, CIAT annual reports, a summary of the Beef Cattle program including both research and training, and a summary of staffing patterns and budgets for CIAT and for the beef program. In addition, the CIAT staff gave the team an intensive briefing on programs during the first day of the review.

The background reading and briefing at CIAT was followed by extensive travel by the team and CIAT staff in Colombia and Brazil. This travel provided an overview of work, both in research and training, being carried out at Monteria and Carimagua in Colombia and at Brasilia, Goiania, Uberaba, Km-47, and Rio de Janeiro, in Brazil.

During and following travel in Colombia and Brazil, many program discussions were held with CIAT staff and management. Concurrently, the team was engaged in intensive meetings and discussions to formulate recommendations and to develop a plan for writing the report. On May 15,a brief oral summary of the salient points contained in this written report was presented to the Board of Directors for CIAT. This was followed by a very productive period of interaction between the team and the CIAT board and staff.

The Beef Review Team is impressed with the progress which has been made by the CIAT Beef Team during the short period it has been working. This progress is a credit to the CIAT board, management, and staff. In short, a competent and committed staff has been assembled and a well conceived program of work is being conducted. Permanent facilities at Palmira are well underway, and in cooperation with ICA, excellent facilities have been developed at Carimagua and Turipana. It is highly significant to note that the CIAT program has preceded the development of permanent facilities. This has been achieved by a very skillful and imaginative use of interim space. As a consequence of rapid program development, CIAT has achieved a great deal of visibility throughout the lowland tropics of Latin America.

One of the basic challenges of the CIAT Beef Program is to develop technology to permit the production of high quality forages on a year-round basis on highly acid soils of relatively low fertility, with an extended dry season presenting a major problem. The Team concludes that for many years in the future, native ranges and forages will provide the major source of animal feeds in the lowland tropics. Hence, the Team supports concentrated efforts directed toward developing systems for optimum utilization of native ranges. At the same time the Team urges continued effort in collecting and evaluating species of superior grasses and legumes and in the development of improved pasture establishment techniques. The Team recognizes that the lack of adequate supplies of adapted seeds is one of the major impediments to the economic development of improved pastures. Thus the Team identifies the employment of a forage agronomist, with responsibility for the development of seed production techniques in the lowland tropics, as being the number one staffing priority for the CIAT Beef program.

In the area of beef production and management, the Review Team concludes that the health program is a strong one which should be continued. The priority need of the health program at this particular time is for an entomologist to carry

out epidemiological studies relating to ticks and tick-borne diseases. Further, there is a need for an economic evaluation of alternative strategies relating to the various health hazards impeding the development of beef production in the lowland tropics. These studies should identify priority areas for health research and training programs. Contrary to the report of the 1968 livestock review team, the present Team assigns low priority to breeding research in CIAT. Rather, the Team concludes that breeding should be a part of the various national programs with CIAT providing consultative and advisory services. On the other hand, the Team assigns a high priority to expanded work relating to the reproduction problem and recommends the addition of a Reproductive Specialist to the Beef program. Finally, the Team wholeheartedly supports the CIAT approach of feeding animals through the soil but recommends some limited work with supplemental feeding, including non-protein nitrogen, preferably with an indigenous carrier source.

The CIAT work to date with production systems is impressive. The Team is particularly impressed with the CIAT effort to identify and to understand existing systems of production as a means of helping structure CIAT priorities for research and training. The Team supports continuing effort in the area of developing and understanding of existing systems. As a part of this effort the Team recommends an extensive study of producer investment behavior to determine what technical, educational, and policy variables have a major impact on beef cattle supply in the lowland tropics. The Team further recommends that priority be allocated to extensive studies of the input and product markets important to the beef industry with particular emphasis on development of an understanding of fertilizer grade phosphate supply possibilities. Similar work is needed for legume and grass seeds. It appears clear that food and cash crops must comprise an important component in livestock production systems in the lowland tropics. The Team supports continued intensive work in this area, with emphasis on small farm development, and urges continued full cooperation with the crops programs in this effort. Finally, the Team recommends continued rigorous economic analysis of various production systems and

recommends a major study to determine the actual economic growth benefits to be derived from beef production as well as an analysis of how the benefits might be distributed among the various economic strata.

The training program of CIAT is impressive. The Team recommends that the staff consider the possibility of the production trainees spending substantially less time on farms and ranches and more time on research stations in close contact with researchers. The Team also recommends that the staff consider the possibility of developing a prototype production unit at Carimagua to be operated by production trainees. The postgraduate intern program is an excellent one and should be continued and possibly expanded. The Team recommends more emphasis on the graduate training program involving thesis research being done at CIAT and urges further development of the special training programs and of shorter term workshops.

Outreach is an important dimension of international institutions. CIAT is engaged in numerous outreach activities. However, the Team strongly recommends that this dimension of the beef program be strengthened immediately. It is the recommendation of the Team that an immediate research outreach be established in another country. Specifically, we recommend that such an outreach be established in the Campo Cerrado of Brazil. This recommendation is based on evidence that results being developed at Carimagua are applicable to the Llanos of Colombia and Venezuela as well as to the Campo Cerrado of Brazil. A research outreach at this time will test this conclusion and serve to verify and extend the results being obtained at Carimagua.

Given its very limited operating budget relative to its mission, CIAT must very carefully choose among alternative locations. The team concludes that CIAT should direct its number one locational priority to the highly acid, low fertility soils as typified by the Llanos and Campo Cerrado areas. This recommendation is based on the high potential for beef cattle increase in these areas and the large

geographic area involved. Although it is true that a relatively small percentage of the cattle in Colombia are now located in the Llanos, the picture changes when the entire lowland tropics are considered and the Llanos and Campo Cerrado are combined. It is specifically recommended that major emphasis, with a full program, be continued at Carimagua and that a limited objective research program be established immediately in the Campo Cerrado of Brazil. The team recommends the number two priority for the area typified by the north coast of Colombia. Serious questions may be raised relative to the adaptability of research results from the station at Turipana because that station is located on a level alluvial flood plain of relatively high fertility, while the cattle are likely to be located on the more rolling low fertility land commonly referred to as the Bolivar Savannahs. Thus the north coast, which contains the major part of the cattle in Colombia,could be continued as a training post with emphasis on the rolling lands, and complemented by major animal health research and training programs at Turipana.

As third priority, at a location to be selected at a later date, the Team recommends the wooded tropics of the Amazon basin. These areas should eventually be of major concern to CIAT as they are typified by infertile and highly acid soils and there are great areas involved in the lowland tropics.

In terms of staffing priorities, the Team recommends that top priority be assigned to the employment of a Forage Agronomist to specialize in seed production and to the employment of two senior members to staff the research outpost in the Campo Cerrado. Specifically, the Campo Cerrado senior staff would consist of one pasture and one Livestock Specialist. The Team would assign a second level of priority to the employment of a Reproduction Specialist to be stationed at Carimagua or to spend a great proportion of his time at that station. The next priority level of staffing would be assigned to the employment of an Entomologist to work with the animal health group, and a somewhat lower priority would be assigned to a Chemist to work in the laboratories at Palmira.

9.0 APPENDICES

APPENDIX A

Review Team Itinerary

Date	From	To	Activity
April 30	Cali, Colombia		Description of Beef Program by CIAT staff (Including all Beef Team Members).
May 1	Cali	Monteria (Col.)	Journey in charter aircraft, visit two collaborating farms in livestock production specialist training project. (Various Beef Team Members).
May 2	Monteria		Morning: Visit ICA Turipana station (Animal Health, Pastures, and Beef Cattle).
	Monteria	Carimagua (Col.)	Journey in charter aircraft. Visit to ICA-CIAT agronomy-food crops experiments.
May 3	Carimagua		Morning and afternoon: Visit pastures and forages, health, herd systems-husbandry experiments.
	Carimagua	Bogota (Col.)	Journey in charter aircraft.
May 4	Bogota		Morning: Discussion.
	Bogota	Brasilia (Brazil)	
May 5	Brasilia		Visit to Dr. Roberto Meirelles and staff in Ministry of Agriculture, and EMBRAPA experiment station.
May 6	Brasilia	Goiania (Brazil)	Journey by car during morning. Afternoon: visit to livestock farm.
May 7	Goiania		Visit EMBRAPA Station and CONDEPE personnel.
	Goiania	Uberaba (Brazil)	
May 8	Uberaba		Visit EMBRAPA Station.
	Uberaba	Rio de Janeiro (Brazil)	Journey in charter aircraft.

APPENDIX A (continued)

Date	From	To	Activity
May 9	Rio de Janeiro		Visit EMBRAPA station at Km-47 and Centro Panamericano de Fiebre Aftosa.
May 10	Rio de Janeiro	Cali (Col.)	
May 11	Cali		Confer with CIAT management and staff and prepare first draft of written report for CIAT Board.
May 12	Cali		Idem
May 13	Cali		Idem
May 14	Cali		Present report to CIAT Beef Team.
May 15	Cali		Present oral report to CIAT Board giving evaluation of and recommendations for CIAT Beef Cattle Program.

APPENDIX B

List of Non-CIAT Research and Training Scientists contacted in Colombia and Brazil

1. Colombia

   a) ICA, Turipana

      1. Dr. Osvaldo Acosta, Director
      2. Dr. Antonio Betancourt, Director LIVET
      3. Dr. Edilberto Polo, Head Pastures and Forages Section
      4. Dr. Luis Reyes, Head Beef Cattle Section
      5. Sr. Enrique Parra, Farmer
      6. Sr. Carlos Giraldo, Farmer.

   b) ICA, Carimagua

      1. Dr. Ismael Torres, Director
      2. Dr. Raúl Pérez, Head Pastures and Forages Section
      3. Dr. Antonio Estrada, Head Beef Cattle Section
      4. Sr. Andrés Paredes, Farmer.

2. Brazil

   a) EMBRAPA, Brasilia

      1. Dr. Roberto Meirelles de Miranda, Technical Director
      2. Dr. José Barcellos, Assistant Technical Director
      3. Dr. Vicente Peloso, Beef Cattle
      4. Dr. Ivo Torturela, Veterinary Medicine
      5. Ing. Leonidas Schalcher Valle, Assistant.

   b) Estaçao Experimental de Brasilia, Brasilia

      1. Ing. Wilson V. Soares, Director
      2. Ing. José Bonifacio de Meneges, Pastures and Forages
      3. Mr. George Naderman, Soils (North Carolina State University).

   c) University of Florida, Beef Cattle Program in EMBRAPA

      1. Dr. Donald Hargrove, Director
      2. Dr. Tony Jilck, Reproduction Program.

d) CONDEPE, Goiania

1. Dr. Isaac Lipman, Director
2. Dr. Virginio de Azeredo, Farm Credit Supervisor
3. Sr. Lourival Gabriel de Oliveira, Farmer.

e) Fazenda Regional de Criaçao de Goiania, Goiania

1. Dr. Pio José da Silva, Director

f) Estacao Experimental de Uberaba, Minas Gerais

1. Ing. Gerson Pereira Rios, Director in charge
2. Dr. Jorge Patricio Gonzalez Sanchez, Animal Health
3. Ing. Marco Antonio de Oliveira, Pastures and Forages
4. Ing. Reginaldo Alfonso de Souza, Soybeans.

g) Instituto de Pesquisas Agropecuarias do Centro Sul, Km-47

1. Dr. Helio Gustavo Guida, Director
2. Dr. Manoel Pimemtel Neto, Parasitology
3. Dr. Jerome Langenegge, Microbiology
4. Dr. Carlos Hubinger Tokamia, Nutrition
5. Dr. Geraldo Verga Ruello, Animal Health
6. Dr. Renauto Luis Pereira de Souza, Animal Production
7. Dr. Adelson Martins Carneiro, Nutrition
8. Dr. Mozart Teixeira Liberal, Horticulture
9. Dr. Hildo Matta, Dairy
10. Dr. Enesio Delgado de Lucas, Agronomy
11. Dr. Johanna Dobereiner, Soils Microbiology
12. Sra. Maria da Gloria de Davila, Soils Microbiology
13. Dr. Auvanic de Almeida Ramoz, Reproduction Program.

h) Centro Panamericano de Fiebre Aftosa, Rio de Janeiro

1. Dr. Mario Fernández V., Director.

APPENDIX C

Beef Program Projects, Sub-projects and Experiments

Centro Internacional de Agricultura Tropical

. Project	No.	Subproject	No.	Experiment [a]
Pasture plant introduction	1.1	Introduction, collection and agronomic evaluation of tropical legumes. Selection of cultivars of forage species adapted to pasture utilization.	1.1.1	Agronomic characterization of Stylosanthes spp.
		Maintain a germplasm bank of tropical forage species as live plants or seed.	1.1.2	Agronomic characterization of Desmodium spp.
			1.1.3	Agronomic characterization of Centrosema spp.
	1.2	Introduction, collection and agronomic evaluation of tropical grass spp.	1.2.1	Grass-legume trial. Four gra species with two varieties of Stylosanthes guyanensis (Carir gua). Determination of dry matter yield, grass legume compatibility, N&P content of pasture components.
Soil microbiology	2.1	Development of suitable inoculant carriers.	2.1.1	Through series of experiments
	2.2	Pelleting as an aid to legume inoculation.	2.2.1	" " " "
	2.3	Strain selection.	2.3.1	" " " "
	2.4	Factors affecting nodulation.	2.4.1	" " " "

[a] Where location is not indicated, experiment is conducted at and/or as related to all present wo sites.

APPENDIX C (continued)

Project	No.	Subproject	No.	Experiment [a]
	2.5	Survival of Rhizobium in soil and strain competion.	2.5.1	Through series of experiments
	2.6	Varietal-Rhizobium interaction.	2.6.1	" " " "
	2.7	Serology.	2.7.1	" " " "
	2.8	Nitrogen fixation in grasses.	2.8.1	" " " "
Forage plant improvement and breeding.	3.1	Development of superior forage cultivars of Centrosema.	3.1.1	Study productivity and stoloniferous development of four hybrid derivatives of Centrosema spp (Palmira).
	3.2	Stylosanthes	3.2.1	Screening Stylosanthes spp. for resistance to anthracnose (Colletotrichum) spp.
	3.3	Pennisetum	3.3.1	Agronomic value of male sterile Pennisetum typhoides crossed with P. purpureum.
Seed production of selected forage sp.	4.1	Field scale seed increase of Stylosanthes and Desmodium spp., Paspalum plicatulum Urochloa mosambicensis for experimentation and regional testing.	4.1.1	Effect of four levels of N on the seed yield of two Brachiaria spp (Palmira).
Pasture establishment.	5.1	Study of practical and economically feasible pasture establishment and range reseeding techniques.	5.1.1	Introduction of Stylo into existing native savannah with and without cultivation and fertilizer (Carimagua).
			5.1.2	Introduction of four Stylos (S. Subsericea, CV Cook, La Libertad CPI 34,000) into native pasture with four levels of P_2O_5 (0, 25, 50, 75 kg/ha). (Carimagua).

APPENDIX C (continued)

lo. Project	No.	Subproject	No.	Experiment [a]
			5.1.3	Introduction of legumes into existing improved grass swards (Carimagu
			5.1.4	Fertilizer requirements for successful establishment of key legumes and grasses in prepared seedbed (Carim gua).
			5.1.5	Introduction of grasses and legumes into native savannahs with different types of strip cultivation: disc, swee V profile wheel, fluted coulter (Carimagua).
			5.1.6	Spontaneous seeding of wind and water transported grasses and legumes from narrow seeded strips across wide strips of prepare and semi-prepared land(Carimagua).
			5.1.7	Differential varietal tolerance to soil acidity among more productive tropical forage species (Carimagua).
			5.1.8	Fertility and lime requirements of Para grass in "esteros" and "bajos" (Carimagua).
	5.2	Maintenance requirements of key legumes and grasses.	5.2.1	Fertilizer requirements including P, K, S, Ca, Mg, Cu, Zn, B, Mo, of key species (Carimagua).
			5.2.2	Lime requirements of new spp. (Carimagua).

APPENDIX C (continued)

Project	No.	Subproject	No.	Experiment [a]
Pasture weed control	6.1	Brush control	6.1.1	Foliar applications of herbicides for broadleaf weeds. (Monteria).
			6.1.2	Basal application of herbicides in diesel fuel (Monteria).
			6.1.3	Use of pelleted herbicides for control of resistant woody shrubs (Monteria).
	6.2	Grass weed control	6.2.1	Control of Paspalum fasciculatum (Gramalote) with post-emergence herbicides (Monteria).
			6.2.2	Life cycle and growth of P. fasciculatum (Palmira, screen house and Monteria).
			6.2.3	Control of Paspalum virgatum (Monteria).
			6.2.4	Control of Andropogon bicornis (Villavicencio).
			6.2.5	Control of Imperata contrata (Villavicencio).
	6.3	Pasture weed identification	6.3.1	An on-going process in the whole zone.
	6.4	Weed competition in pastures.	6.4.1	Losses due to brushy species in pastures (Monteria).

APPENDIX C (continued)

o.	Project	No.	Subproject	No.	Experiment [a]
7.	Pastures and forage utilization.	7.1	Grazing management and production potential of tropical pastures.	7.1.1	Growth rate and fattening of steers grazing Molasses grass (Melinis minutiflora) in the Llanos with fertilization of P and K under three stocking rates (Carimagua).
				7.1.2	Growth rate of steers grazir native savannah in the Llano under 2 systems of manag ment and 3 stocking rates (Carimagua).
				7.1.3	Establishment, survival and animal production of Stylosanthes guyanensis mixed wi 4 grasses in the Llanos (Carimagua).
				7.1.4	Comparative beef productior of pure Para grass pastures and in mixture with tropical legumes (Monteria).
		7.2	Systems of beef production under intensive grazing conditions.	7.2.1	Beef fattening system on Pangola grass fertilized with nitrogen and under irrigation (Palmira).
				7.2.2	Beef fattening system on Para grass fertilized with nitrogen, without irrigation (Palmira).

APPENDIX C (continued)

Project	No.	Subproject	No.	Experiment [a]
	7.3	Nutritive evaluation of tropical forages.	7.3.1	Measure intake, digestibility and nitrogen balance using unsupplemented forages.
			7.3.2	Determine effect of supplementation with protein, urea, and minerals on utilization of pasture forages.
			7.3.3	Nutritive value of legumes, especially Stylosanthes.
			7.3.4	Nutritive value of introduced graminae (e.g. Hemarthria altissima, Ele-tift) (Palmira).
			7.3.5	Nutrient intake on native pasture. (Projected Carimagua).
			7.3.6	Nutrient intake on improved pastures. (Projected Carimagua).
upplemental eeding.	8.1	Breeding herd	8.1.1	Effect of nitrogen and mineral supplementation on reproductive performance (Carimagua).
	8.2	Calves (pre- and post-weaning).		
	8.3	Growing-finishing.		

APPENDIX C (continued)

o.	Projected	No.	Subproject	No.	Experiment [a]
9.	Intensive systems of growing-finishing in confinement	9.1	Cultivated forages	9.1.1.	Growing-finishing cattle with Elephant grass (Palmira).
		9.2	Crop residues, by-products		
		9.3	Fermentation products.		
0.	To devise specimen Animal Health programs for beef cattle in the lowland tropics.	10.1	Monitoring and identification of diseases and parasitisms.	10.1.1	Routine diagnostic procedures with initiation of further investigation if required (Carimagu ranches on the Costa Atlantica included in livestock productio training course).
		10.2	Identification, epidemiology and control of breeding diseases.	10.2.1	Search for pathogens known to cause infertility or abortions (Carimagua and Villavicencio slaughterhouse).
				10.2.2	Epidemiology and importance of granular vaginitis (Carimag
				10.2.3	Etiology of "vaca inflada" (Palmira).
		10.3	Identification, epidemiology and control of hemoparasitic diseases.	10.3.1	Identification of hemoparasites (Carimagua, Turipana, Palmi
				10.3.2	Development diagnostic techniques (Palmira).

APPENDIX C (continued)

Project	No.	Subproject	No.	Experiment [a]
			10.3.3	Development immunization procedures (Palmira).
			10.3.4	Field trials immunization procedures (Turipana).
			10.3.5	Identification of ectoparasites and their role as vectors (Carimagua).
			10.3.6	Determination of wild animal involvement in the epidemiology of tick borne diseases (Carimagua).
			10.3.7	Factors determining the abundance of ticks (Carimagua).
			10.3.8	Epidemiology of Trypanosoma vivax (Palmira).
			10.3.9	Epidemiology of Trypanosoma evansi (Carimagua).
	10.4	Identification, epidemiology and control of helminth infections.	10.4.1	Helminth infections in relation to vegetation, microclimates and host density (Carimagua and Turipana).
Agricultural economics	11.1	Description and characterization of the beef cattle industry in the lowland tropics of Latin America.	11.1.1	Aspects of the cattle industry in the north coast region of Colombia.

APPENDIX C (continued)

Project	No.	Subproject	No.	Experiment [a]
			11.1.2	A description of the Colombian beef cattle sector.
	11.2	Marketing of beef cattle and meat in Colombia.		
	11.3	Economic evaluation of experimental results.	11.3.1	A study of the use of an integrated control program for hemo, endo and ecto parasites in cattle in the north coast of Colombia (economic considerations).
			11.3.2	The influence of nitrogen fertilization and stocking rate on return of capital invested in fattening cattle on pasture (Palmira).
2. Production Systems	12.1	Food crop production.	12.1.1	Screening of food crops for acid soil tolerance (Carimagua).
			12.1.2	Fertility requirements of food crops N, P, K, Ca, Mg, S, Cu, Zn, B, Mo. (Carimagua).
			12.1.3	Summer production of vegetable and food legumes under irrigati using Carimagua windmill (Carimagua).

APPENDIX C (continued)

Project	No.	Subproject	No.	Experiment [a]
	12.2	Farm structures	12.2.1	Low cost, simple windmills.
			12.2.2	Low cost water tanks.
			12.2.3	Efficient use of native materials for family dwellings and other farm buildings.
	12.3	Herd systems	12.3.1	Determine effects of management, Molasses grass, protein supplementation, breeding season, cross-breeding, early weaning in life cycle production systems (Carimagua).
			12.3.2	(Projected) Efficiency and profitability of production systems on native and improved grass with and without tropical legumes, and performance of cross-bred females vs. grade Cebus (Carimagua).
	12.4	Family farm units	12.4.1	Prototype units to test components in integrated package (Carimagua).
			12.4.2	Pilot units off station with ranchers (Carimagua).
			12.4.3	Training units to further test components in livestock and crop production. In cooperation with training division (Carimagua).

APPENDIX C (continued)

Project	No.	Subproject	No.	Experiment [a]
	12.5	Farm surveys	12.5.1	Determine (a) standard of living, (b) number, production level, physiological, health status of beef cattle,(c) problems and potentials on small to medium sized ranches that receive cattle on shares from Fondo Ganadero del Meta.