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Pasture Improvement Research in Eastern and Southern Africa

Proceedings of a workshop held in Harare, Zimbabwe, 17–21 September 1984

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Pasture Improvement Research in Eastern and Southern Africa

Proceedings of a workshop held in Harare, Zimbabwe, 17–21 September 1984

Editor: Jackson A. Kategile

Cosponsored by the
Southern African Development Coordination Committee, Gaborone, Botswana,
and the
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Abstract: The proceedings contains reviews by national scientists on pasture research done primarily in Eastern and Southern Africa (Ethiopia, Kenya, Tanzania, Burundi, Zambia, Zimbabwe, Swaziland, Lesotho, Botswana, Mozambique, and Madagascar). The application of the results obtained and lessons learned are highlighted and used in setting of national priorities for research areas for the future. Critical reviews on current pasture research methodologies are included in the proceedings. The research methods discussed are germ-plasm collection, storage, and dissemination; and germ-plasm introduction and evaluation, nutritive evaluation of pastures, grazing experiments, and range monitoring. Specific guidelines on methodologies are outlined and these are useful to pasture agronomists, animal nutritionists, and range-management scientists.

Two case studies of pasture-research regional networks in Asia and Latin America were presented and discussed. A strategy for future pasture research coordinated through a regional Pastures Network for Eastern and Southern Africa (PANESA) was discussed and agreed upon.

Résumé: Dans les actes ci-joints, des scientifiques de divers pays analysent la recherche entreprise sur les pâturages en Afrique orientale et australe (Éthiopie, Kenya, Tanzanie, Burundi, Zambie, Zimbabwe, Lesotho, Botswana, Mozambique et Madagascar). L'utilisation des résultats obtenus et les connaissances acquises sont mises en lumière, puis utilisées pour établir les priorités nationales en matière de recherche. Les actes comportent une analyse critique des méthodes de recherche actuelles sur les pâturages : rassemblement, entreposage et diffusion du matériel génétique; mise à l'essai et évaluation de ce matériel; expériences de pâturage; évaluation nutritive des pâturages et exploitation rationnelle de ceux-ci. On présente des lignes directrices précises sur les méthodes à suivre, qui seront utilies aux agronomes en charge des pâturages, aux spécialistes de la nutrition animale et aux scientifiques responsables de la gestion des pâturages.

Deux études de cas ont fait l'objet d'une présentation suivie d'une discussion : il s'agit des réseaux régionaux de recherche sur les pâturages en Asie et en Amérique latine. Après discussion, on a convenu d'une stratégie de la recherche sur les pâturages, dans les années à venir; la coordination de cette stratégie sera assurée par une section régionale du Pastures Network for Eastern and Southern Africa (PANESA).

Resumen: En las actas se recogen ponencias presentadas por científicos de diferentes países sobre las investigaciones en pastos que se han realizado principalmente en el Africa oriental y meridional (Etiopía, Kenia, Tanzania, Burundi, Zambia, Zimbabwe, Suazilandia, Lesotho, Botswana, Mozambique y Madagascar). Se destaca la aplicación de los resultados y experiencias obtenidos, muy útiles para determinar las prioridades de las investigaciones futuras en las diferentes naciones. En las actas se recogen también ponencias críticas sobre las metodologías empleadas actualmente en las investigaciones sobre pastos. Se analizan los siguientes métodos de investigación: recogida, almacenamiento, diseminación, introducción y evaluación de germoplasma; evaluación del valor nutricional de los pastos; experimentos de pastoreo; y control de dehesas. Se resumen directrices y metodologías específicas de gran utilidad para agrónomos especializados en pastos, expertos en nutrición animal y científicos especializados en gestión de dehesas.

Se presentan y analizan dos estudios de casos de las redes regionales de investigación en Asia y Latinoamérica. Se discutió y aprobó una estrategia para realizar investigaciones sobre pastos en el futuro que serán coordinadas por la Red de Investigaciones sobre Pastos para Africa Oriental y Meridional (RIPAOM).

CONTENTS

THEORY AND PRACTICE IN FORAGE GERM-PLASM COLLECTION

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Abstract *The collection of forage germ plasm requires careful planning so that the sampling of plant variation both within and between environments is efficiently accomplished. Plant variation is acquired by sampling larger numbers of sites across more environments and greater distances. Observational data on the plant and environmental data on the site of accession are valuable in that they can reduce the effort required in screening.*

COLLECTION THEORY

Improvements in tropical and subtropical forage productivity have depended largely on the identification of natural genotypes of grasses and legumes that are productive and persistant under economically viable management systems. However, the variation in many species of known forage value has been little explored and a great number of other species with forage potential have received no attention at all. Collection is thus an important tool for the improvement of forage production.

Collection of germ plasm is necessary when appropriate germ plasm of the range of variation desired for testing for specific environmental and management conditions is not available from commercial sources or existing collections of experimental material. It is undertaken in response to a direct request or in return for germ plasm supplied by an institution, as a scientific study to determine what germ plasm is available and what variation is present, to preserve germ plasm of potential forage value that is threatened with extinction, and to form a representative collection for breeding or for future use.

Value of the Germ Plasm Pool

Work on the evaluation of the forage potential of natural genotypes has barely begun. Little genotypic evaluation has been done on even the commercially important species of tropical grasses. A recent list of tropical herbaceous and browse legumes of potential or actual commercial value on which some research had been done contained 143 species (Skerman 1977), while an estimated 3,800 species have potential forage value (Williams 1983).

Africa is the continent with the largest number of endemic grass genera and, thus, is the most important centre of grass variation. The vigorous growth, response to fertility, and resistance to grazing of many of these African genotypes has made them the most successful forage grass species in the subtropics and tropics of other continents, most notably in the Americas and Australia (Parsons 1972; Harlan 1983). In many areas, such genera as Panicum, Hyparrhenia, Brachiaria, Cynodon, and Digitaria are sufficiently well adapted and aggressive to have become widely naturalized. Clayton (1983) noted that 27 out of 45 important tropical grass species have their distribution centred on Africa, seven are centred on the Americas, and the Mediterranean and Asia have one each.

Although the primary centre of tropical legume diversity is Central and South America (Williams 1983), Asia and Africa are important secondary centres of diversity. Africa is a centre of origin of such commercially important legume genera as Neonotonia, Aeschynomene, Lotononis, Macrotyloma, Lablab, Vigna, and Trifolium (Harlan 1983; Thulin 1983). Other agronomically important genera that are represented in Africa include Stylosanthes, Desmodium, and Zornia.

Characteristics of Forage Plants

A good pasture plant must be productive, aggressive so as to rapidly colonize the area in which it is sown, and be capable of persisting and retaining its dominance despite invasion and competition by native flora. It must propagate easily, produce seed readily and in quantity, be adapted to the climatic and edaphic environment of the target area, be resistant to pests and diseases, persist and retain its leaves under periods of drought, and be resistant to cutting, trampling, or grazing and yet have some degree of palatability. It should be productive under low fertility but also respond to fertile conditions. The ability to be used for other purposes than forage is an advantage, e.g., for human nutrition, thatching, fuel.

Plants for cut and carry or carefully managed grazing can have good palatability but in mixed grass-legume swards that are not carefully managed the legume should be no more palatable than the grass so that it is not grazed in preference and, thus, eliminated from the sward. Lower legume palatability is also an advantage in establishment when oversowing grass swards and in the conservation of fodder as standing legume hay for a dry season when its high nutritional value will enable low-quality grass to be more efficiently digested by grazing animals.

Identification of Collection Areas

Plant collection and introduction is based on the general premise that plants will grow successfully in environments similar to those in which they were collected (Burt and Reid 1976; Burt et al. 1976, 1979; Reid 1980). Experience has shown that this is usually the case. Plants also frequently do better in similar environments geographically distant from their origin (Burt and Williams 1975). This is presumably due to their removal from diseases, pests, and competing vegetation that have evolved at the same time. Examples of such successful movements of plants include alfalfa (Medicago sativa) from the Mediterranean region to the Americas and Australia, Stylosanthes humilis from tropical America to Australia, and Panicum maximum and Hyparrhenia rufa from Africa to Central America. Thus, productive forage germ plasm for research programs in Africa should be sought not only in the program area but also from geographically distant areas including those on other continents. It also follows that germ plasm that is unsuccessful in one region may be very successful elsewhere.

However, once pests or diseases have evolved or been introduced, the productivity of the introduced germ plasm can be severely curtailed. The introduction of alfalfa aphids to the USA and Australia has severely affected alfalfa production and necessitated the establishment of screening programs to locate resistant germ plasm for breeding programs. The introduction of anthracnose (*Colectotrichum gloeosporioides*) to Australia severely affected the productivity of sown and naturalized stands of *S. humilis* and has essentially eliminated it as an important forage species.

Tropical environments are extremely varied. Factors such as amount of rainfall, length of dry season, altitude, and soil pH, texture and fertility are all important when selecting areas for collection, or sites for the testing of accessions. Although most plants have some degree of adaptability and can grow in a range of environments, the range of environments in the tropics is so large that careful examination is required to determine in what part of the range of each factor a plant would be expected to be productive. Because of the large numbers of accessions currently in collections, it is important to pay attention to the environment of origin when collecting so that all accessions do not have to be tested in all environments and, at least initially, can be tested in environments in which they are likely to be successful.

Because newly cleared or ploughed areas are disturbed environments and grazing and cutting maintains swards in a subclimax or disturbed condition it is not surprising that the aggressive plants required as forages are commonly found in subclimax vegetation and disturbed sites. Climax vegetation in contrast can be less aggressive and persistent (Harlan 1983). The edges, ditches, and margins of roads are the most commonly disturbed sites seen on collection trips; however, the environments and germ plasm present may have little in common with the adjacent, less altered environments. Although there may be species present that have invaded such disturbed sites from adjacent environments it is common to have a high proportion of germ plasm that has been transported from elsewhere.

Sampling Strategy

The sampling strategy adopted by a collector will depend upon the aims of the collection. These can be categorized as: (a) a general collection, a survey to sample the variability in the germ plasm present or to preserve variability of germ plasm threatened with extinction, in an environment or environments; (b) environmental collection, collection of species that occur in a specific environment; and (c) specific species collection, the collection of one or more species of known or potential forage value.

In general collection, to sample variation, transects are made across the environment or environments concerned. Collection stops are made fairly regularly along the transects, modified by environmental considerations. Stops are made in areas where several environments can be examined at once, and an effort is made to sample all of the environmental variation present in the area being collected.

General collection forms a continuum with environmental collection because a specific environment may be defined broadly, over a substantial area; for example, areas with a 4-month dry season, or narrowly, with collection limited to a few, small locations such as areas of Vertisols with a 4-month dry season. In the latter case, transects are done of these target environments across regions with each target environment on the transect being transected in turn, or environmental variations sampled within it.

In collection of specific species, transects are made across the environments where the species is known to occur. To determine the adaptability of the species, collection is also done in other environments that occur within, or adjacent to, the environments of known occurrence.

In practice, there is an overlap of these strategies. In general collection, species of known or suspected forage value are given more attention than those of unknown value, and more attention is given to environments where these are likely to occur. When specific plants or environments are collected it is unusual not to do some collection of other interesting or unknown species and adjacent environments. Normally, such plants are collected at stops whether or not the target species is present. In time, plants that are toxic, not grazed, or of no agronomic interest will be identified and ignored. Thus, serendipitously, the flora is sampled and, in time, fairly good collections of forage germ plasm will result that have at least some representatives of most plants of potential value.

Collection transects should be chosen carefully in relationship to the goals of the collection mission. Some environmental factors of particular importance are total annual rainfall, length of dry season, growing season temperatures (mean temperature, lowest monthly mean minimum temperature, and frost occurrence), soil type, texture, pH, drainage, and fertility.

Numbers of Plants Sampled per Site

Collection is done to acquire the useful variation in germ plasm of specific plants or groups of plants. It is pertinent then to know how many plants of each species should be collected at a site to acquire representatives of at least the more common genes.

Most tropical legumes and grasses are apomictic (self-fertile) with little outcrossing. If useful genetic variability is defined as alleles at a locus with a population frequency of greater than 5%, conservatively, 50-100 plants should be sampled per species per site. Outcrossing species, such as the highland perennial Trifolium, require seed from fewer individuals. A truly self-incompatible, random mating plant would, theoretically, require a sample of only 100 seeds from any plant (Marshall and Brown 1983).

These theoretical numbers of plants are, in practice, only occasionally found at one site, particularly in the case of legumes. As well, a site may have a variety of edaphic environments or distinctive plant phenotypes. These are usually collected separately. The norms for sampling accessions of tropical legumes are: one plant, a few plants more or less in a group or adjacent groups, or a few widely scattered plants. If the plants are self-fertile, it can be assumed that all of the plants in one group are likely to be similar, if not identical. More broadly scattered plants are likely to have more variation, but they too may be essentially identical and considered to be one accession.

Due to environmental factors, the appearance of plants at the collecting site cannot be used with any assurance to predict genetic similarity or variation. Plants that are similar when collected can be quite dissimilar when tested under uniform conditions, and the converse may be true (Schultze-Kraft 1979b).

When variation in edaphic environment or in phenotype suggests genotypic variation may be present, it is probably simpler to collect the variations as separate accessions, recording the observed distinctive characters. If the suspected variations are all put into one sample it will require particularly careful attention in the screening phase to differentiate the variations present within the accession, and these may not show up under the screening conditions. Accessions that are relatively uniform genetically are easiest to screen and describe.

The emphasis in collection of variation is better put into collecting more sites and environments than achieving the theoretically optimum number of plants at one site (Reid and Strickland 1983).

Amount of Seed per Accession

Because collecting is done to acquire variation in germ plasm and few accessions will be considered sufficiently promising to develop immediately (perhaps one in a thousand) it is inefficient to collect more seed at one site than is required for a plot or a few pots for initial evaluation, description, and multiplication. The International Livestock Centre for Africa (ILCA) uses up to six potted plants for initial multiplication and up to six spaced plants in a plot for initial evaluation.

One or more seeds is sufficient for a collection; 20 may be adequate but more than a few hundred can be a waste of time. If an accession is particularly promising and rapid multiplication is desired, more rapid than can be achieved by ordinary means, the original site can be re-collected to acquire a bulk sample.

Number of Accessions in a Collection

There is no single rule as to what number of accessions should form a "collection." Much depends on the amount of variation that is found in a species, or area, the variation in environments in which a species occurs, and the demand for different genotypes to broaden the range of adaptation or to fulfill a specific role.

Enough germ plasm of a species has normally been collected when survey collections have been done over its range at appropriate times of the year and the material collected has shown no particular promise; when a species has been shown to have no agronomic value; when other species are given priority and, thus, germ plasm of an originally important plant is solely collected when it appears at a collecting site (which in practice is only occasionally in this phase for plants which are very common), and when there is more germ plasm collected than can be handled in 1 year. No special effort is made to collect numbers of species with no apparent or unknown value. A particular species must compete with other species of potential for the collectors attention, thus, the numbers that constitute a collection of a given species are directly related to its agronomic interest.

Species that are of primary interest such as *Stylosanthes fruticosa* should be collected on transects throughout its range, to the extremes of its environmental adaptation. If on screening variation is noted, further collection can be done in areas of interest to attempt to sample the extent of the variation. When specific collections of species of agronomic importance are collected to locate resistance to diseases or pests, e.g., anthracnose in *Stylosanthes*, the question of numbers of accessions is less important.

Rate of Collection

Collection is normally done at a rate determined by the interest in the species to be collected, the frequency of occurrence of the target species, the ease of access to the collection area, the stamina of the collector, the money and time available, the length of the collecting season, and the capability of the supporting infrastructure to accession, multiply, evaluate, and store the material. Large forage research centres handle 1,000 to 2,000 lines a year.

Data Recorded at the Collection Site

For early collections, field notes were written that included such environmental and other data as the individual collector felt were important in relation to the particular research program and target environment. Numbers of accessions were small and notes tended to be brief.

With much larger numbers of accessions and the wide testing of collections, information on the accession and the environment of collection has become much more important because not all lines can be tested at all sites, and such information reduces the amount of screening required (Burt et al. 1979). The availability of computers has made the handling of such data readily manageable. Thus, the demand these days is for more data rather than less.

Important environmental factors that should be recorded include those of climate, soil, associated vegetation, imposed management, disturbance, and incidence of pests and diseases. A precise description of the location is required so that the site, or particular plant, may be re-collected if necessary, and so the information obtained from climatic and edaphic maps will be as accurate as possible (Reid and Lazier 1979; Isabell and Burt 1980; Reid and Strickland 1983).

Legume/Rhizobium Association

The Rhizobium/plant association is an important factor in the value of legumes as forages because the associated bacterium provides the plant with atmospheric N in a useable form. Plants may readily form nodules with rhizobia commonly found in the soil, in which case they are referred to as belonging to the "cowpea group." Many pasture plants, however, have requirements for specific rhizobial species or genotypes, and when moved to a new area there may not be such appropriate rhizobia present. The plant will, thus, produce much below its potential. This specificity of requirement may be generalized within genera (e.g., Desmodium) or may be specific for a genotype within a species that is normally broadly associative (e.g., Sxylosanthes guianensis as a species generally nodulates with the cowpea group of rhizobia, however, the commercial cultivar of S. guianensis, cv. Oxley, has specific requirements). Laboratory tests have shown that even members of the cowpea group can show significantly better growth with certain Rhizobium strains (Gibson and Brockwell 1968; Mannetje 1969; Trinick 1982).

It is apparent then that rhizobia should be collected for each genotype; however, few countries have the facilities and staff for propagation, storage, and testing of this germ plasm and fewer could handle the numbers involved. Perhaps a compromise that is better than no collection or too large a collection of nodules is to collect them from species of particular interest in distinctive environments. As far as tropical and subtropical forage Rhizobium are concerned, the Commonwealth Scientific and Industrial Research Organization, Australia (CSIRO) and Centro Internacional de Agricultura Tropical, Colombia (CIAT) are two organizations that are interested in and have facilities capable of handling some lines, and the FAO-funded MIRCEN group may be able to handle some as well.

COLLECTION TRIP

Reference Material

To ensure that the trip is efficient, producing useful and varied germ plasm with the least expenditure of time and money, careful planning is required (Schultze-Kraft 1979a; Reid and Strickland 1983).

Herbaria should be visited because they can provide information on what species and germ plasm are available and where and when the collection should be done to acquire ripe seed. Not only specimens of species with known forage potential should be examined but also a search should be done through the genera to locate new species and genotypes with forage potential.

Topographic, climatic, and soil maps should be used to identify regions for collection with elevation, climates, and soils similar to the target environment or, in the case of survey collections, to plan routes that transect environments. Important climatic factors include the mean growing-season temperature, minimum temperatures in the growing season, frosts, length of the dry season (or growing season), and rainfall. Soil factors of particular importance are pH, texture, depth, drainage, and fertility.

These environmental factors will influence the genotype present and the likelihood of its adaptation at the target area. Land-use maps will detail current utilization of the target areas or transects. Areas that are grazed are likely to have grass and legume species and genotypes adapted to survival under grazing, whereas high rainfall forest areas have more climbing vegetation that is better adapted to cut and carry. Long-established road margins and fields usually have a greater variation in species than newly cleared areas. Introduced species are found in these areas, although some of the species originally native to the area may have disappeared due to clearing or grazing.

People with local knowledge should be consulted, botanists who have collected in or studied the region, agronomists who have worked in the area, and people who have visited the region or who live there. These contacts should be able to answer questions on the ecology, farming systems, accommodation, and roads. The more information that is available before a trip, the better equipped the collector (Appendix 1) and the less arduous and more successful the trip.

Administrative Organization

Permission for the collection trip should be obtained from the government concerned well before the trip begins. Care must be taken that the objectives of the trip and the locations where collections will be made are well described and a time table is provided. Travel permits may be required for travel in some areas, other areas may be closed to travelers. For those working within the government services of the country in which the collection is to take place, such permissions should not be difficult to obtain. Letters of introduction should be acquired, particularly to government authorities; these may be particularly useful when the mission runs into difficulties. All conditions set by this government should be carefully met. For example, half of the seed may have to be left with a national program, or the seed may have to be multiplied before any leaves the country. In cases where half the seed has to remain, when there are 20 seeds or less, the collecting organization is normally allowed to take all of that line to multiply it, returning an agreed amount to the country of origin.

Arrangements should be made before the collection trip for multiplication, long-term storage, and agronomic description and initial evaluation of the germ plasm collected.

Time of Collection

The time of the year chosen for collection will be largely determined by the expected time when mature seed will be available of the species of greatest interest. Many other species will not have ripe seed at that time. Thus, it is important to record at each site the other legumes present and whether they have shed their seed or whether they as yet have only green seed. This will help plan future trips to collect these lines in a period of the year when they are ripe. The same locations can then be collected. When there is no mature seed, seed may be found on the ground, or vegetative material may be collected.

Staff Considerations

There is little reason why one person cannot form a collection expedition. That person should be at least at a graduate level or be a technician with several years experience, familiar with forages and with their utilization, and preferably with some exposure to the methodologies of experienced collectors.

One particularly good reason for having a second person on a collecting trip, however, is that the trip and the collection can still continue if one member is tired or ill. The second person can be a technician who should be able to drive, assist with soil and rhizobial sampling and seed collection, or can be another collector, a local counterpart, or even a soil scientist who can be of assistance in recording the environmental data.

The personal health of the staff is an important factor on collection trips because illness can ruin a collection trip and delay a program for a year. Collectors should not exhaust themselves, should take care that proper rest and food are taken, and that precautions are taken against intestinal and other diseases.

Route

As access limits the efficiency of collection, the collection route and collection stops are planned by superimposing the soil, climate, altitude, land use, and herbarium data on a detailed road map. This is not to suggest, however, that collection is to be restricted to main roads. Side roads, farm roads, and tracks should be utilized. In regions that have few roads, collection of important environments must be done by horse, mule, donkey, or on foot. The route is planned to include as many target environments and transects as possible.

Collection Stops

The method of selecting collection sites varies with the environmental variation and the sites to be collected. Basically, there are three methods: (a) stopping along a route at regular intervals, (b) stopping only at locations of interest or of variation, and (c) some combination of (a) and (b). The number of collection stops in a given distance of road will depend on the distance that has to be traveled in a day. In practice, an 8-hour collection day is sufficient to exhaust most collectors, and the energy and enthusiasm wanes rapidly as the day is prolonged, fewer notes are taken, and the quality of the work deteriorates. Even over shorter distances, about 13 stops a day is probably a maximum.

If the stops are chosen by distance, then stops are usually made at locations where there is some environmental variation and several locations can be sampled at one site, i.e., a plain (the dominant feature), a valley wall, a river bank, and areas with and without grazing and wetter and drier areas.

Legumes may occur in considerable abundance at certain locations and be completely absent in adjacent locations with apparently identical environmental conditions. Thus, when a collection stop is made and there are no legumes at the road edge, in fields, or in the nearby environments, then the location and environment should be briefly recorded as well as the fact that there were no legumes present. Other stops should be made in the vicinity, in spots where there are environmental variations. Legumes can usually be found after two or three such brief stops. For efficient collection, a well-organized daily routine is required (Appendix 2).

The Data Sheet

Both simple and detailed observations at collection sites have been described previously (Reid and Lazier 1979; Reid and Strickland 1983). ILCA in the past has used a generalized collection sheet (Appendix 3), but has, with the initiation of a computer program to handle the data, moved to a more detailed collection sheet where specific questions are asked and are organized in the same manner as the computer data base. Not all questions will be relevant or answerable at a given site. However, the more information that is recorded the more likely it is that an accession will be tested in an appropriate environment. The data sheet and the definitions of the data to be collected are presented in Appendix 3.

Although much information can be obtained by observations made at the collection site an important but often neglected source of information on the forage value of native plants is the local farmer or grazier. This is particularly true in Africa where livestock owners are usually closely associated with their animals. Local information is especially useful for browse species because the screening of these is much more difficult than that of herbaceous legumes or grasses and several years growth is usually required to obtain basic information.

Although information from one farmer may be misleading, conversations with a number of farmers will provide more reliable data because it is common to find a species considered to be unpalatable in one area yet be quite acceptable fodder in another. Such variation may be due to the availability of alternative fodder in times of stress.

Collection of Rhizobium

A critical factor in the collection of Rhizobium germ plasm is that most seed collection is done in the dry season when the soil may be impermeable and the plant roots difficult to excavate. Also, nodules are sloughed by the plant in the dry season and there may be no viable nodules present to collect. If this is the case, and if warranted, the collection sites should be returned to in the wet season and nodules collected at that time. The soil should not be too wet because rhizobia do not thrive in saturated soils.

The actual collection is a simple matter. Sealable vials have a small quantity of dessicant (anhydrous $CaCl_2$ or silica gel) put in and held at the bottom by a light wad of cotton wool. Ten to fifteen nodules ideally are collected from each plant, cut from the root about half a cm on each side. The volume of the plant tissue should not exceed that of the dessicant, which should be about 25% of the volume of the vial and the vial should also be labeled. ILCA staff use the plant accession number with an R prefix to identify the Rhizobium, however, a separate numbering system may be given to the Rhizobium accessions in the microbiology laboratory (Date and Halliday 1979; Strickland et al. 1980; Date 1982).

Herbarium Specimens

A well-managed collection and screening system will have herbarium specimens of all accessions so that there is some record of the plants' growth form, to check if the original genotype is what is being grown, for genetic variation studies within species and genera, and to help determine if outcrossing is occurring.

Although each plant collected could be pressed during collection in the field this is an unnecessary burden on the collector. Such specimens may be in very poor shape, not flowering or modified by drought, grazing, etc. Thus, on collection trips just specimens of unknown species normally are pressed. The collected genotypes can have herbarium specimens taken from multiplication plots where more uniform conditions prevail and where samples that are flowering and seeding can be readily obtained.

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APPENDIX 1: TRIP EQUIPMENT

A vehicle appropriate to the roads to be encountered should be taken. If spare parts are not available along the route, spares should be taken following the advice of a mechanic who knows the vehicle. Spare tires, extra petrol, patching kits, tire pump, shovel, machete, pick, and a tow rope are among essential equipment for remote areas.

Personal equipment should include changes of clothing; sunglasses (as glare can bother the eyes when searching for legumes and legume seed); a large hat; an umbrella (one can collect and make records in the rain); medicine; particularly for headache, common cold, and diarrhoea; and a medical kit, which should include tweezers for removing thorns, insect repellent, mosquito net, mosquito coils, insecticide for bed bugs, water container.

Basic Collecting Equipment

Data: collection sheets and clip board, or collection book.

Planning: road maps with important environmental boundaries marked on, or photocopies of environmental maps, topographic maps, altimeter if available, metal tape measure, and compass.

Soil samples: soil auger, pH kit, plastic bags for soil samples, waterproof labeler for soil samples (pencil or indelible pen), and waterproof labels for inside and outside of soil sample bags.

Seed samples: rubber-sided threshing boards; envelopes for seed samples, good quality; stapler to close envelopes, plenty of staples, staple remover; larger paper bags to contain bulky seeds and to organize envelopes; herbarium press, plenty of newspaper, cardboard sheets cut to size, jewelers tags to label plants; notebook or diary; camera and film; rubber bands; plant presses (2); insecticide (household spray with some residual properties); fungicide.

Vegetative material: sturdy shovel, pick, trowel, plastic bags, water container, shears, pruning saw (for browse), adhesive tape for closing plastic bags, box or bag for storage (Walley and Brown 1973).

Rhizobia: shovel, pick, hand trowel, sealable vials, vials with cotton wool and silica gel or $CaCl_2$, scissors, tweezers, container for vials.

Browse: tree secateurs.

Hearts and minds: small gifts for those helping out.

APPENDIX 2: DAILY ROUTINE

Breakfast early, or as soon as restaurant opens; purchase lunch if there will be none available en route; purchase soft drinks and/or replenish drinking water. In hot weather one is sipping all day.

Record the odometer reading of the vehicle to the nearest 10th km, if possible, at a fixed point in the town, e.g., main intersection, town hall, etc. Continue to do this at each town during the day to keep the site location accurate. Also at each new road, record the odometer reading at the beginning.

Calculate the number of stops possible during the working day. About 13 stops is maximum for a day. Plan the day's stops on the map recording the odometer reading for the chosen sites.

At each collection stop, the odometer reading should be recorded, and the vegetation and site should be described. What legumes and grasses are present should be recorded whether seed is present or not. This will allow future collections to be made at the site.

Stop collecting when tired, it is important not to exhaust oneself to avoid illness that can ruin the trip. The last collection should be about 16:00 or 16:30 hours depending on the time started, distance yet to be traveled, condition of the road, and energy of the collectors.

Either before or after dinner, the plant presses should be opened and the newspaper changed if wet;

notes on the day written up; accession sheets reread, made more legible and more detailed; the day's collection of seed cleaned, insects and damaged and diseased seed removed, and insecticide and fungicide added. The next day's travel and collecting stops planned in the light of experience to date; check that the collected vegetative material is in good shape.

APPENDIX 3: ILCA ACCESSION/COLLECTION SHEETS

There are two ILCA detailed Accession/Collection sheets and one general accession form. The two Accession/Collection sheets together provide the information that has been selected as being valuable and likely to be available either at the site of accession or in references elsewhere.

Accession sheets may be of two sorts, those with few general questions and large spaces for answers, or those with many specific questions and small spaces for answers. As computer data organization is based on many specific questions, these sheets have many specific questions to be answered. This means the transfer of data from the collection sheet to the computer does not require the collector to interpret the notes, and data may be entered by a typist. It also means that information that might have been forgotten or overlooked is included.

All questions will not be answerable at a given site or be pertinent. However, if the answer is no or none, it should be written as such. Descriptors without answers are not used in the description of the accession. Collectors should do their best when filling in the sheets at the site of collection to remember that the more information that is included, the more likely that the accession will be useful.

The forms are organized to follow the sequence of input into the computer and to provide a logical sequence of questions in the field.

Sheet I has 3 parts:

(a) General site data -- this section is filled in only once for each general site of collection.

(b) Data from references -- is completed in the office or laboratory after collection.

(c) Field data -- on the reverse of Sheet I, this is completed using a separate sheet for each accession.

The sheets from one site may be fastened to the sheet that has the General Site Data section completed.

Sheet II is filled out in the office or laboratory after collection is completed. It is fastened to Sheet I. It is also used as the only accession sheet for commercial lines of germ plasm for which little or no data are available.

ILCA Accession/Collection Sheet Definitions

Sheet I Species: scientific name (genus and species).

ILCA: The ILCA accession number -- leave this blank (or forms may be prenumbered).

A. General Site Data
Fill this section out in the field once only for each collection site. A site may have many accessions. Section C, Field Data, is filled out for each accession on separate sheets.

Collection site no: Sites for each mission are numbered by the collector consecutively, beginning with number 1. All accession sheets for one site are stapled together.

Collection date: Day, month, year, (as numbers) e.g., 10/12/1984.

Collector's accession numbers at site: Accession numbers assigned by the collector at the site, copied from Section C, Field Data. The numbers of all accessions collected at this site are to be recorded here.

Collectors: The initials and name of each member of the collecting team are recorded here in the same order each time.

Collection institute: The name of the institute(s) with which the collection is associated.

Country collected: The country in which the sample is collected.

State, district, and area: To be obtained from a political map.

Altitude: If an altimeter or a topographic map is used in the field, this may be filled in in this section. Altitude may also be completed in the office and, thus, there is a space in Section B, Data from References.

Exact site: An exact description of the location. The more detailed the description, the better, e.g., along Addis Ababa - Debre Berhan road 20 km (or 20.3 km if possible) from the Shola dairy at the E edge of Addis Ababa. At about 200 m past a small bridge where 2 houses are 50 m E of road, the site is 10 m E of road edge, at the W edge of a Eucalyptus grove.

General site comments: Further details of the general site may be added here if desired, for example, a general description.

B. Data From References

This section is filled out on return to the office after collecting.

Map: reference: From a topographic map of a scale of 1:250,000 or smaller if possible (i.e., 1:100,000). Information given should include map series number, sheet number, edition, and map grid reference, i.e., Ethiopia series EMA 3, sheet NC 37-10, ed. 2, 37B PA 2662, or more accurately 37B PA 265623.

. Latitude - From the topographic map in degrees (°), and minutes (') (60 minutes to 1 degree). Circle whether north or south.

. Longitude - From the topographic map in degrees (°), and minutes ('). Circle whether east or west.

. Altitude - From an altimeter reading that would have been recorded in Section A, General Site Data, in the field, or from a topographic map. If they differ the topographic map should have preference.

Ecological zone: From an ecological map give the general zone, i.e., Guinea savanna, and any specific descriptors, i.e., southern.

Rainfall: Annual in millimeters. Obtain from the nearest and most applicable station. If stations lie on either side of the site, and rainfall changes regularly between them, then the rainfall of the site can be estimated, i.e., collection point A lies 2/3 of the distance between town B with 1,200 mm rainfall and town C with 900 mm rainfall, and closer to town C. If the topography is fairly uniform and rainfall is assumed to diminish regularly between towns B and C, rainfall at point A will be 1,000 mm.

. Seasonality - Give the months in which rainfall occurs. The rainy season(s), for example, in a bimodal rainfall could be (a) January-March, (b) July-September.

. Length - The total number of months in which Lsignificant rainfall occurs. The number of months in the rainy season(s).

Temperature: There are several important temperature parameters that may be available for a site. The growing season temperatures are, of course, more relevant than mean annual temperatures. However, to allow greater utilization of the data, as many of these variables as available should be recorded.

. Mean - The mean annual temperature in degrees Celcius, calculated as for rainfall.

. Average maximum - The average maximum temperature in degrees Celcius.

. Average minimum - The average minimum temperature in degrees Celcius.

. GS mean - The mean temperature during the growing season in degrees Celcius.

. GS mean coldest month - The mean temperature

(°C) during the coldest month of the growing season.

. GS mean warmest month - The mean temperature (°C) during the warmest month of the growing season.

. GS mean minimum coldest month - The mean minimum temperature (°C) during the coldest month of the growing season.

. GS mean maximum warmest month - The mean maximum temperature (°C) during the warmest month of the growing season.

. Frosts - Occur with what frequency (0 nil - 5 frequent) and severity (0 nil - 5 very severe).

Soil: Parent rock - Fill in this section from a geological map if this could not be determined in the field (there is a "parent rock," in Section C under Field Data): sandstone, limestone, shale, granite, basalt, gneiss, alluvium, tuff, laval, etc.

. Names - Fill in this section from a soils map if the soil could not be identified in the field and was not recorded under Field Data. Use whatever system is available, i.e., USDA, FAO, etc. If several names are available, list them all. Include a local class, subclass, and phase if available.

. pH - The pH is best done in the laboratory from a soil sample. It may also have been done in the field and recorded under Field Data. State the method used (H_2O, KCl). There is also a space in Section C under Field Data if the pH is determined in the field.

Analysis: Chemical - List the results from soil analyses of at least major nutrients and the analytical methods used.

. Physical - List the results of the soil analyses for the soil fractions; clay, sand, etc.

Rhizobium number: This will be given in the laboratory. It will consist of the plant's accession number with the suffix R, e.g., ILCAR 6259. In the field, the vial with Rhizobium should be given the collector's number of the accession from which it was taken.

Herbarium specimen: The location of a stored pressed specimen and the person who identified it should be recorded here.

C. Field Data

Each accession at a site must have a separate sheet with Field Data recorded. All the accession sheets for each site are then fastened to the sheet that has the General Site Data section completed.

Site number: The same number that was given to the site in the General Site Data section.

Collector's number: The accessions are numbered consecutively. The number will be followed by the initials of the trip leader. Although numbers may start at 1 from each trip, it is perhaps wiser to have only one of each number in existence for a trip leader. He could thus have increasingly larger collection numbers over the years.

Genus, Species, Subspecies, Variety: Complete if known.

Flowering:* Relative number of flowers. As in all headings marked with an asterisk (*) a 0-5 ranking is used. No flowers = 0, to completely flowering or a great many flowers = 5.

Seeding:* As for flowering, i.e., 0 = no seeds, 5 = all flowers mature.

Ripe seed:* Proportion of mature seeds or seed pods. 0 = none, 5 = all seeds present are mature.

Leafy:* Relative leafiness of the plant. 0 = no leaves, 5 = completely covered in leaves, a very leafy plant. Do not compare the plant to the leafiest you have seen of the species, but to a theoretical plant of the same growth type completely covered in leaves.

Height: The height of the plant in cm.

Spread: The plant diameter in cm.

Morphology: Tree, shrub, herb, vine.

Density:* The number of plants at the collecting spot, from one plant = 1, to a dense patch = 5.

Relative abundance:* The relative abundance of the number of plants in the general area, from 0 = no other, to 5 = very common.

Grazed by: Specify what animals: cattle, sheep, camels, deer, voles, etc.

Intensity:* -The degree of grazing from 0 = none, to 5 = very heavily grazed.

Diseases: Name - The common name, or genus and species if known. Fungus or bacterium if only that much is known.

. Parts affected - Leaves, stems, roots, infloresconse.

. Damage (/10) extent - This is an observation of the percentage (recorded out of 10) of the organs affected, e.g., for a leaf disease, an 8 indicates that 80% of the leaves have the disease.

. Intensity - Again this is recorded as a percentage out of 10 and gives the average damage to the affected leaves, e.g., an observation rating of 5 indicates an average of 50% of each affected leaf is damaged. This is useful where the leaves are more or less uniformly affected. If they are not, the ratings could be recorded as a range, e.g., 1-8.

. Description - Describe disease and its effect on the plants.

Pests: Name - The common name, or genus and species, if known, type of pests, e.g., insect, nematode, or other.

. Parts affected - As for diseases.

. Damage (/10) extent - As for diseases.

. Intensity - As for diseases.

. Description - Sucking, boring, chewing, etc. Describe pest and its effect on the plants.

Management: The management of the site of collection. This involves any regular, human-directed treatments of the environment or plant. This may include grazing, irrigation, mowing, etc.

Management detail: Specific detail on above management conditions. Inquire from local residents.

Fire: When was the area last burned over? How often does this occur?

Aspect: The direction of the slope of the land in degrees, e.g., 350°.

Slope: Record in words, or degrees if measured. 0-1° flat or almost flat, 1-3° moderately sloping, 7-14° sloping, 14-29° steep, and greater than 29° very steep.

Topography: Rolling, flat, etc.

Position in landscape: At the bottom of a steep cliff, half-way up a small hill, etc.

Soil: Parent rock - If it is known in the field, sandstone, limestone, shale, granite, basalt, gneiss, alluvium, tuff, lava, etc.

. Name - If you recognize the soil type in the field, vertisol, nitosol, etc. plus the name in any other system you may know.

. Colour - Dark gray, mottled, dark red, light brown, black, etc., or give the code from Munsell's chart.

. pH - If the pH is taken in the field, record it here and the extracting solution, i.e., 5.9, H_2O.

. Texture, sand - Loose and single grained, see or feel individual grains; when dry it falls apart when squeezed in the hand and released; when moist, a cast of squeezed material remains but crumbles when touched.

. Silty-loam - Lumpy (clods) when dry but can be readily broken; feels soft and flourery when pulverized. When wet readily runs together and puddles. Forms cast dry or wet that can be freely handled without breaking but when moistened and squeezed between thumb and finger will not ribbon but gives a broken appearance.

. Clay - Breaks into clods or lumps that are hard when dry. When pinched between thumb and forefinger it forms a thin ribbon that breaks readily, barely sustaining its own weight. Plastic, forms a cast that bears much handling. Kneeded in the hand it does not crumble readily but forms a heavy compact mass.

. Loam - A rather even mixture of sand, silt, and clay. A somewhat gritty feel, fairly smooth, slightly plastic. When squeezed when dry it forms a cast that requires careful handling. Moist casts can be handled freely without breaking.

Drainage, surface: 0 = Ponded - water passes through soil, or evaporates, no runoff.

. 1 = Very slow runoff - free water lies on surface or enters soil immediately, level or porous soil.

. 2 = Slow runoff - water covers soil for significant period or enters soil rapidly, nearly level, gently sloping, little or no erosion when cultivated.

. 3 = Medium runoff - water covers soil for short periods, a moderate proportion enters soil; slight to moderate erosion when cultivated.

. 4 = Rapid runoff - a large proportion of the water moves rapidly over the surface, only a small part goes into the soil, runs off as fast as it is added, low infiltration capacity, moderately steep to steep slope, moderate to high erosion hazard.

. 5 = Very rapid runoff - very little infiltration, water runs off as fast as added, steep to very steep slope, low infiltration capacity. Erosion hazard high to very high.

Drainage, internal: 0 = No free water passes through particularly when water table at the surface.

. 1 = Very slow - too slow for growth of important crops. Saturated for 1-2 months. Blotched or mottled in nearly all parts of the profile, some gray surface soils. May be due to high water table, a very slowly permeable horizon or both.

. 2 = Slow - affects the roots of most plants; saturated with water for 1 or 2 weeks. If slow internal drainage then black or gray A horizon, mottling or blotching in the lower A or upper B, lower B and C. Relatively high permanent or fluctuating water table.

. 3 = Medium - water saturation limited to a few days, less time than required to injure plant roots. Optimum for growth of important crops under humid conditions, most soils free of mottling and blotching through A horizon and all or most of B.

. 4 = Rapid - water saturation only for a few hours. Drainage somewhat too rapid for important crops of humid regions.

. 5 = Very rapid - soil never water saturated, too droughty for important crops of humid regions. Free of mottlings for several feet.

Plants Sampled: No. = Specify the number of plants sampled, 1 (the best sample) or more.

. Material - What material was collected: seed or vegetative.

. Rooting habit - Deep tap root, shallow tap root, deep spreading, shallow spreading, fibrous.

. Nodules collected - Yes/no

. Herbarium specimen - Yes/no

. Photograph - Not taken (record no), or if taken record the number of the photo.

. Local name - The name of the plant used by the people in the area where it was collected.

. Ethnic group/language - The language of the local name, or the name of the ethnic group.

. Habitat - Description of the site in some detail, and the location of the plant within the site.

. Disturbance - Disturbance differs from management in being nonregular and/or not caused by man and may include such treatments as bulldozed area, road margin or ditch, eroded, flooded, logged.

. Vegetation type - Forest, woodland, grassland, desert, etc. If possible record the full scientific name, i.e., Acacia tortilis woodland with Chloris gayana and Hyparrhenia hirta.

. Associated grasses - List the scientific or common names of the grasses found at the collection spot. Indicate which are dominant in the habitat.

. Legumes: As for grasses.

. Others: Herbs, shrubs, trees, etc., as for grasses.

. Comments: Any other information that you feel would be of use in interpreting the adaptability of the plant, i.e., an assessment of general vigour or potential.

Sheet II

This sheet is filled out in the office or laboratory for each collected accession and fastened to Sheet I. Acquired accessions, such as commercial lines may have only this information available. Thus, just Sheet II is required without Sheet I. Most of the definitions are either obvious or given on the sheet.

Growth zone: This descriptor is used to simplify catalogue preparation. As it is very difficult to classify accessions according to growth zones, species, and genera that are mainly in, or dominate in, a given environment are grouped there, no matter where collected. This avoids arbitrary delineations between temperate and subtropical, and the same species appearing in several groupings in a catalogue. More precise groupings can be obtained by grouping on altitude and temperature.

Plant type: This descriptor is again used to simplify catalogue preparation. Again the division of genera or species into browse or legume is arbitrary, however, as some system must be followed, perhaps the simplest is to classify all members of a given species as browse or herbaceous legume, whether all the members might fit the definition or not. Examples of two general of which members may be considered herbaceous legumes or browse are Aeschynomene and Desmanthus. The main rule should be: be consistent.

Genetic status: These definitions are designed to suit cereal and cultivated crops as well as forage crops.

. Wild - Not cultivated, persists without the intervention of man.

. Weedy - Not cultivated, but required the intervention of man.

. Primitive cultivar/land race - a cultivated crop, not necessarily consciously bred.

. Breeders line - a consciously bred line, advanced cultivar, a selected breeders line, released commercially.

Parentage: The genetic makeup of bred lines.

Other accession numbers: List all other accession numbers known for the line. This will greatly reduce duplication in a collection.

Source: Where did the seed come from originally, if not a collection? Be certain to include the name of the scientist involved. Include other sources from which the seed is received.

ILCA Accession Sheet — General Form

Species: ______________________ Accession no.: ______________

Date: ________________________ Collector: ________________

Site location: ____
____
____
____
____
____
____

Map reference: ____
____

Latitude: __________ Altitude: __________ Rainfall: __________ mm

Temperature: ______ °C Morphology: __________ Flowering:* __________

Seeding:* ________ Ripe seed:* __________ No. plants sampled: ______

Leafy:* ______ Height: ______ cm Spread: ______ cm Density:* ______

Relative abundance:* __________ Grazed:* __________ by: __________

Fire: ______________ Aspect: __________ ° Slope: ____________

Texture: ______________________ Parent rock: ________________

Drainage: (surface) ______ (internal) ______ Ph: ______ Photo: ______

Soil name: ____

Habitat and disturbance: ____________________________________
____
____
____
____
____
____

Associated species: ____
____
____
____

Remarks: ____
____
____
____
____
____

* Ranked 0 to 5.

ILCA Collection/Accession Sheet I

Species: ____________________ ILCA no. ____________________

A. GENERAL SITE DATA

Collection site no. ____________________ Collection date ___/___/___

Collection accession numbers at site ____________________

Collectors ____________________

Collecting institute ____________________

Country collected ____________________ State ____________________

District ____________________ Area ____________ Altitude ________

Exact site ____________________

____

____

____

____

____

____

General site comments ____________________

____

____

____

____

B. DATA FROM REFERENCES

Map: reference ____________________

____

latitude _____° _____' N/S, longitude _____° _____'E/W, altitude _____

Ecological zone: general ____________________, specific ____________

Rainfall: annual _____ mm, seasonality (mo) (a) ____________________

length ____________ mo. (b) ____________________

Temperature: mean _____°C, average maximum _____°C, average minimum _____°C

growing season (GS) mean _______°C GS mean coldest mo. _______

GS mean warmest mo. _______°C GS mean min. coldest mo. _____

GS mean max. warmest mo. _______°C frost: frequency* ____________

Soil: parent rock ____________________ name(s) ____________________

____________________ pH ____________

Analysis: chemical ____________________

physical ____________________

Rhizobium: number ____________________

Herbarium: specimen stored where ____________________

identified by ____________________

* Observed on a scale of 0 (least) to 5 (most).

C. FIELD DATA

Site no. ____________ Collector's no.____________

Genus____________ Species____________

Subspecies ____________ Variety____________

Flowering*___ Seeding*___ Ripe seed*___ Leafy*___ Height ___cm Spread ___cm

Morphology ____________ Density*____________ Rel. abundance*________

Grazed by ____________ Intensity*____________

Diseases: name____________ parts affected____________
damage (/10) extent____________ intensity____________
description____________

Pests: name____________ parts affected____________

damage (/10) extent____________ intensity____________

description____________
Management____________

Management detail____________

____

Fire____________ Aspect____________° Slope____________

Topography____________

Position in landscape____________

Soil: parent rock____________ name(s)____________

____________ colour____________ pH______ in______

texture____________ drainage: surface________ internal*______

Plants sampled: no.____________ material____________

Rooting habit____________ Nodules collected______ Herbarium specimen______

Photograph______ Local name____________ Ethnic group/lang.____________

Habitat:____________

____

____

Disturbance____________

Vegetation type____________

Associated: Grasses____________

____

Legumes____________

Others____________

Comments:____________

____

____

____

____

____

* Observed on a scale of 0 (least) to 5 (most)

ILCA ACCESSION SHEET II

(To be attached to Collection Sheet I, or alone for accessions with no data on site of origin.)

Species:________________________________ ILCA no.:__________

Subspecies:_____________________________ Authorities:__________

Variety:____

Convariety:____

Cultivar:________________________________ Acc. date____/____/____
d m y

	Genus	Species	Sub sp.	Variety	Authority
Synonyms 1					
2					
3					
4					

Longevity: annual/biannual/perennial

Growth zone: temperate/Mediterranean/tropical/subtropical/highland tropical

Plant type: herbaceous/legume/grass/browse/cereal/other

Genetic status: wild, weedy, primitive cultivar/landrace, breeders line, advanced cultivar

Parentage:____

____

Crop name:____

Other acc. nos.:____

Source: name____

organization____

address____

other sources____

____

____

____

____

Comments:____

____

____

____