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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).

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INTRODUCTION AND EVALUATION OF LARGE GERM-PLASM COLLECTIONS

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Abstract *The framework is given within which to conduct a program for the assembly and evaluation of a collection of pasture plants. Aspects dealt with include objectives of the program, whether to breed from the collection or select for direct use, how to carry out the preliminary and detailed evaluations, maintenance and seed increase, determination of the areas of adaptation, and commercial release.*

The assembly and evaluation of collections of tropical pasture germ plasm have been well described in the literature over recent years. The material available ranges from individual chapters, such as Williams (1964), Shaw et al. (1976), and Williams et al. (1976) in more general books on tropical pasture research, to specific books on the subject, e.g., Mott (1979) and Clements and Cameron (1980). As well, McIvor and Bray (1983) discuss the whole subject of the genetic resources of forage plants.

These publications detail the different approaches that can be taken to the assembly of a collection and its subsequent maintenance and evaluation. They show different approaches, that may, at first sight, seem difficult to reconcile. These differences arise for various reasons, including different objectives of the programs, different types of material being handled including the different breeding systems, different levels of facilities available to conduct the programs, and last, but by no means least, different philosophies as to how such an evaluation should be undertaken.

It is not my intention to attempt to reconcile these various approaches, but rather to present a framework (Fig. 1) within which rational decisions can be made as to how to tackle the particular problem at hand.

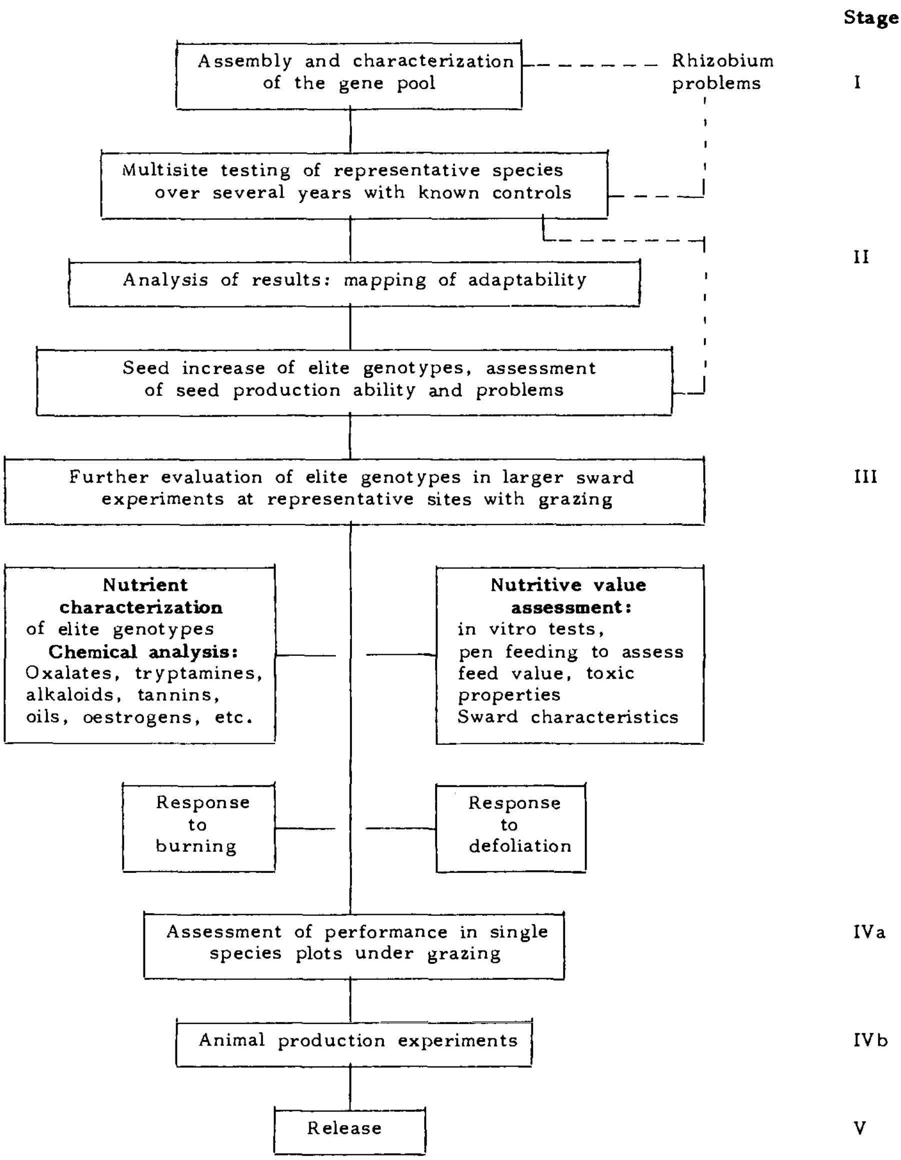

Fig. 1. Scheme for evaluation of introduced pasture species (source: Jones and Walker 1983).

DETERMINATION OF OBJECTIVES

One of the most important steps is to define clearly the objectives of the program. This will affect the approach taken both in assembly and in evaluation phases. Is the objective to provide a complete suite of pasture plants for use in an area where sown pastures have not previously been used, or is the objective simply to refine an existing array of cultivars, some of which are deficient in certain features, such as ease of establishment, palatability, or productivity? Is the objective to plug gaps in an existing array by providing plants for special uses, such as legumes for use on heavy clay soils, or has a widely used and valued plant broken down due to the advent of a new disease or insect pest? All these objectives require collections of greater or lesser complexity to be assembled. If a breeding program is required to provide a new disease-resistant cultivar, the collection may be monospecific. If full-sown pastures were required for an area where presently there were none, then both grasses and legumes and possibly even forage crops will be required. For this, a very broad-ranging collection will be assembled.

The nature of the local livestock industry and the size of the area to be serviced will also influence the defined objectives. Different plants are required where livestock feeding is by "cut and carry" as opposed to extensive, free-range grazing. Similarly, a much more extensive collection will be necessary if a large area is to be serviced rather than just a restricted locality.

BREEDING VERSUS DIRECT USE

There is great fascination, in some quarters, with plant breeding as a means of providing new forage plants, but breeding in pasture plants can be much more difficult and less rewarding than for crop plants. Unless there are very specific and clear objectives, such as inducing fertility in valuable, but sterile, material, or transferring disease resistance, pasture plant-breeding objectives are difficult to define and even more difficult to achieve. Dry matter yield is a poor objective. The inefficiencies in conversion of dry matter to animal product mean that rather large differences between yields of pastures often give virtually no differences in animal product. Differences in various characteristics (e.g., seasonal production pattern, digestibility, palatability and hence diet selection, and forage quality) tend to nullify differences in dry matter yield. A low-yielding, persistent plant is often more useful than a high-yielding one that is not well-adapted to the local pasture ecosystem and so has to be very carefully managed or one that produces its main bulk at a noncritical time of the year.

Before a breeding program can be implemented, the collection of available material has to be evaluated and the strengths and weaknesses of every accession assessed in an agronomic as well as a genetic sense. It is often a short, and much quicker, step to take the best of the collection directly into pasture use. Breeding is a slow, time-consuming activity. Representative variability of the species to be bred must be available, but reproductively incompatible plants cannot be used. This latter feature tends to restrict those lines being taken through the preliminary stage. This stage is identical for either breeding or direct use, so material with potential for direct use is excluded from the preliminary evaluation phase.

It is recommended that, for developing areas, the initial approach should be to provide new pasture plants directly from the naturally occurring genotypes of all potentially useful species. Breeding programs should be undertaken only where locally valuable plants have collapsed under pest or disease stresses, or are showing some clear and readily corrected defect. The first requirement for a successful breeding program is a well-qualified, enthusiastic plant breeder. Breeding programs have a habit of developing into exercises in genetic science that have little value in practical plant-improvement programs.

ASSEMBLY OF A COLLECTION

Before collection of material begins, the objectives should be defined and two other points attended to:

(a) Assemble a full description of the environment of the target region(s) in which the selected material is to be used. This applies especially to climate and soils. Similar areas in other countries should be sought as sources of material for test (Reid 1980). If this can be done, it can substantially reduce the number of unsuitable lines included in the collection and so reduce the work involved in its evaluation.

(b) Become thoroughly familiar with your local plant import and quarantine requirements. This ensures the smooth entry of all material without any losses arising from failure to meet all import formalities. Quickly establish a working relationship with the appropriate officials so that they know you and the objectives of your program.

If there are no or few quarantine requirements, give consideration to establishing such a system within your program. This ensures that no unwanted pests and diseases come in with seed or planting material (Jones 1980). Ensure that material being included in the program has no local weed potential. A good maxim in this regard is "if in doubt - out" take in only material that you are sure is disease-free or has no weed potential and destroy all other samples.

The defined objective will determine the scope and complexity of the collection that needs to be assembled. There are four major sources of seed:

(a) Commercial trade: For areas where sown pasture development has not been attempted previously, the first step is to examine all commercial material, available in other countries, that may suit your local environment. This material is already domesticated and ready for commercial use if it proves adapted. The source can be the commercial seed trade. Samples can be as large as can be afforded.

(b) Major international collections: There are now a number of major germ plasm collections, such as those at Centro Internacional de Agricultura Tropical (CIAT) in Colombia, Empresa Brasileira de Pesguisa Agropecaria (EMBRAPA) in Brazil, International Livestock Centre for Africa (ILCA) in Ethiopia, and Commonwealth Scientific and Industrial Research Organization (CSIRO) in Australia. They will provide small experimental samples of seed, especially if you are able to supply exchange samples of local material or material from other sources not already in their collections. Correspondence with the Officers-in-Charge of the collections is all that is required. Some of these centres will also provide small quantities of local commercial seed. A detailed description of your target environment will help them select material to forward to you.

(c) Smaller institutional collections: Most research centres involved in plant impovement maintain some sort of a germ plasm collection, even if it is only their current working stock. They are usually quite willing to provide small samples and can be most useful, especially if located in areas already determined as matching your target area. They often have local ecotypes, not yet in the major collections. Correspondence is all that is required.

(d) Field collection: This can be a simple assembly of all the more promising wild ecotypes within your local region(s), or those collected on an extended international collecting trip. Either way, the procedures are the same. (See the relevant chapters on preparation, collection, and data recording in Mott (1979) and Clements and Cameron (1980).) The local material should be assembled as a matter of course early in the program, both for formal testing and use as control lines and for use as exchange seed with outside collections. The major international collecting trip is more of a last resort. Unless it can be associated with other major reasons for travel, it should be undertaken only when other possibilities have failed to provide useful material.

GERM-PLASM MAINTENANCE

At the beginning of the program, attention should be given to maintenance of the germ-plasm stocks as they are assembled. This is necessary both before and after the particular lines have been evaluated. It is often necessary to return to the original sample, if only to check that a confusion of identities has not occurred somewhere during evaluation. This happens even in the best-run programs. For this purpose, two factors require attention: a numerical register of all samples should be established to identify individual seed lots, and a secure seed storage facility should be developed.

Storage should provide protection against vermin and insect damage and provide cool dry conditions conducive to maintenance of viability. Seed under ambient conditions in hot-humid areas will lose its viability in less than 12 months. A cool, dry cellar, suitably vermin- and insect-proofed, can serve this purpose. It will give some years of life to the seed. It should be possible to retrieve seed quickly from the store whenever it is required.

No matter what storage is available, arrangements should be made for periodic regeneration of the stocks and, more important, for the increase of selected samples for further testing. Regrowing should take account of the isolation needed to maintain the genetic integrity of the samples (Luse 1979; Williams et al. 1980).

PRELIMINARY EVALUATION

The preliminary evaluation of any collection is routine, no matter what the future intention for the material. It is a familiarization process to get to know the strengths and weaknesses of each species and accession. It should be carried out as soon after receipt of samples as possible. Preliminary evaluation is not only a detailed recording of various characteristics of the individual accessions but also the development of a personal understanding of the material, often in a most unscientific but very useful fashion. It can commence in the quarantine glasshouse if the material is accessible at that stage.

The technique used will depend on the quantities of seed available. For very small samples, care should be taken to ensure establishment of each individual seed. Barriers to germination, such as hard seed coats or dormancy, should be removed. Protection from diseases and pests should be provided and ideal germination conditions used. Seedlings are frequently raised in individual pots (used paper drinking cups are useful) and planted out into the field as spaced plants. Where larger samples are available, they can be planted directly into the field, in solid nursery rows. Either way, it is wise not to use more than half the seed available at each attempt at establishment. Probably, only one planting a year will be possible.

The nursery should be on an even area, free from changes in soil texture and fertility, and be well-drained and weed-free. A thorough seed bed preparation should be carried out and adequate base fertilizer applied before planting. Any weeds that do appear should be promptly removed. Irrigation should be available, unless rainfall is very reliable, to ensure establishment of all material planted, but no irrigation should be used after establishment. Legumes should be inoculated with appropriate rhizobia or arrangements made for regular light applications of nitrogen fertilizer (25 kg N/ha/month) to ensure growth potential is reached. This also applies to accessions that fail to nodulate despite inoculation. A search should then be initiated for suitable rhizobia. At all stages through the evaluation, similar local plants should be planted as standards against which to assess the performance and likely future value of test material.

Where possible, replication should be used, but this is often omitted at the initial nursery stage. Arrangements should also be made for initial seed increase for future testing. Allowance will need to be made for the breeding system of the plants in the allocation of material to plots within the nursery. A few accessions of one cross-pollinating species can be distributed widely through the nursery without too much risk of genetic contamination, but a large number of potentially crossing lines of one species may require separate isolated sites for seed increase.

Note-taking should be frequent and comprehensive at this stage and is facilitated by an appropriate data sheet prepared in advance of the first recording. These should cover the characteristics considered most desirable to record for local purposes plus initial establishment. For at least 2 years and preferably longer, flowering time, drought, frost, insect and disease reactions, habit of growth, leaf and stem peculiarities, seed set, holding and shattering, seed size, potential seed production, and plant and stand persistence should also be recorded. Retain the nursery for as long as possible, allowing animals periodic access in later years, noting plants not readily grazed. See Mott (1979) and Clements and Cameron (1980) for several possible types of forms and full details of initial evaluation.

At this stage, the species identification of all samples should be confirmed or adjusted as far as is possible. All potential weeds that have slipped through earlier screenings should be removed. Where there are a substantial number of accessions of one species or genus within the collection, efforts should be made to classify these into like groups. This classification can be a simple intuitive grouping of lines or a highly sophisticated computer exercise. Its objective is to allow the reduction of the number of accessions that have to be grown in the next phase. It is carried out, if possible, at the end of the preliminary evaluation phase.

DETERMINATION OF AREAS OF ADAPTATION

Where the primary nursery is serving a large area, as much of the material as possible should then be planted widely throughout that area. Where groupings of very similar lines have been made, only one or two representatives of each group need to be taken further at this stage. If these turn out to be extremely promising at certain sites, then further representatives of that group, or even the whole group, can subsequently be grown at those sites.

The methods used for this determination are relatively unimportant, ranging from simplified nursery techniques, to cultivated strips in native grasslands, or even small swards. See Cameron and McIvor (1980) for the cultivated strip technique (Fig. 2) that has been found useful in northern Australia. The important point is to standardize between sites to enable direct comparison across all sites. Note-taking in this phase is much reduced relative to that in the main nursery. This phase permits the assessment of what lines are likely to prove useful in different areas. Some will show wide adaptation and continue, initially, to be grown widely. Others will show only localized value at a few closely related sites, e.g., on wet low-lying land. At the end of this stage the collection should be grouped into categories of differing adaptation and potential uses.

DETAILED EVALUATION

Once areas of adaptation within the collection are known, the numbers of accessions tested further at

Fig. 2. Establishing a legume strip in native grassland for experimental evaluation.

each centre can be drastically reduced. Depending on the resources and facilities available, evaluation may be concentrated in a few of the more important districts or may be continued widely through the region. It may concentrate on grasses at one centre and legumes at another, or on different legume genera at different centres. Until this stage has been reached, little quantitative data will have been collected. Now the best 20-30 accessions can be subjected to detailed assessment for final selection. The techniques used and measurements made will be influenced by the objectives set out

Fig. 3. Small-plot cutting trials with grasses at South Johnston Research Station in Queensland.

before the program commenced. Proceed through all or some of the following stages.

(a) Small-plot, cutting trials (Fig. 3): Usually monospecific, these permit seasons of productivity and reaction to defoliation to be assessed. Plots are small, 2 x 2 m or less if seed is in short supply. Some plants may require larger plots. Due to the removal of cut material and the drain on soil fertility, fertilizer applications should be heavier than those that are made on grazed plots. Measurements will include establishment and persistence of plant populations, periodic dry matter yields, and ingress of weeds.

(b) Small-plot, grazed trials: These may be somewhat larger plots, which are grazed after each yield assessment is made (from a small sample area), to give a better pasture environment for assessment. Relative palatabilities, in particular, should be noted. Duration of these trials should be at least 4 years to give some assessment of persistence under grazing.

(c) Legume/grass compatibility: These trials can involve either all legumes with a standard grass and vice-versa or a legume/grass grid in which the legumes under consideration are planted in long narrow strips in one direction with the promising grasses in similar width strips at right angles. Each grass x legume segment should be assessed separately. Five legumes x 5 grasses gives 25 separate subplots to measure per replicate, so numbers are large if the grass and legume accession numbers are high. A minimum of three replications should be used for all trials in this phase. (For further details see Cameron and McIvor 1980.)

Any problems such as establishment difficulties or special nutritional requirements should be investigated at this stage and a solution identified before the material is taken into further detailed studies. Close attention should be given to any seed production problems (Hopkinson and Eagles 1980).

GRAZING ASSESSMENT

The grazing should provide a final assessment of the true worth of a pasture plant but poses questions that are very difficult to answer. It is rarely possible to simulate, in grazing studies, the type of use to which practical farmers will subject their pastures. As a result, the final determination of worth can come only from commercial use. It is not proposed to describe grazing trials in detail here (see, for example, 't Mannetje et al. (1976) and Jones and Walker (1983)), but careful thought should be given to matching the local use patterns as far as possible, using local types of livestock and grazing management regimes. A range of stocking rates should be used.

The more sophisticated the local pastoral industry, the greater the need for grazing studies in the final selection process. Minimum monitoring is that of animal product alone, milk yield, or liveweight gain, but, where possible, pasture parameters should also be measured to know what is happening in the pasture (Cameron and McIvor 1980).

SEED INCREASE AND RELEASE TO COMMERCE

At the time the first seed stocks are made available to commercial seed producers, a cultivar name should be selected and publicized. Before this release can occur, the initial seed stocks have to be increased.

The initial commercial phase is often handled by a seed increase committee with representatives drawn from the agronomists, seed producers, seed merchants, and farmers. This committee will supervise production techniques and disposal of seed by the first commercial seed producers (Hopkinson 1980).

It is at this stage that consideration should be given to the need for seed certification. With many tropical species, such as apomictic grasses, it is generally not required, especially if they have easily recognizable features. Seed certification is an expensive and time-consuming activity that should be avoided if possible. When there are several potentially cross-pollinating cultivars in production, seed certification becomes essential.

During the precommercial increase phase, there will be seed stocks that are of inadequate quality for further multiplication purposes. However, these contaminated stocks can be used to familiarize extension officers and landholders with the new material. They can be used for demonstration plantings throughout the areas where it is intended to use the new cultivar.

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