

# Trends in on-farm performance testing of cattle and sheep in sub-Saharan Africa

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## SUMMARY

*THIS PAPER reviews the need for, and the objectives of, performance testing in the African production environment. The zonal distribution of cattle and sheep populations is discussed, and the major factors limiting animal performance are highlighted. Past, present and future trends in performance testing are then assessed and the advantages and disadvantages of on-farm and on-station performance recording are evaluated.*

## INTRODUCTION

Sub-Saharan Africa has a great need and considerable potential for increased production from cattle and sheep. Both species are functionally integrated into farming systems, and there is a clear association between particular breed populations and particular ecological environments. Before animal performance under the prevailing ecological and economic conditions can be improved, detailed information is needed on the specific functions of cattle and sheep in production systems, on their performance potential under different levels of management, and on the current disease situation and feed availability. Such information can be obtained through livestock performance testing on stations and on farms.

This paper summarises past and present experiences with livestock performance testing in sub-Saharan Africa and outlines the role of networks in improving on-farm testing through the use of standardised testing methods and rapid data handling and feedback.

## CATTLE AND SHEEP PRODUCTION SYSTEMS

### Populations

Sub-Saharan Africa is a diverse ecological environment comprising arid and semi-arid rangelands, subhumid and humid lowlands and temperate highlands, and characterised by an association of specific breed types with particular ecological zones. The distribution of cattle and sheep populations by zone is shown in Table 1, the highest concentrations of these species being in the drier and highland areas.

**Table 1.** *Distribution of cattle and sheep populations by ecological zone in sub-Saharan Africa (SSA).*

Zone	Land area (% of SSA)	Cattle (%)	Sheep (%)
Arid	36	20.7	35.7
Semi-arid	18	30.6	22.2
Subhumid	22	22.7	13.6
Humid	19	6.1	7.9
Higland	5	19.9	20.6

Source: Jahnke (1982).

About 75% of all livestock in sub-Saharan Africa are kept by smallholders (agropastoralists or mixed crop–livestock farmers), about 20% by pastoralists and only 5% on ranches. African livestock production systems are directed towards economic security and food production. Smallholders and pastoralists aim at maximising returns per unit land area, rather than returns per animal. Specialised production systems are gradually appearing, but only in ecologically and economically favourable areas such as the Kenyan highlands. Most specialised herds are very small, which considerably limits opportunities for within-herd selection.

Livestock have diverse economic and social functions in African farming systems. They provide foods, inputs to crop production in the form of traction and manure, and fibre and skins. Contrary to common belief, most livestock production systems in sub-Saharan Africa are output oriented and cannot be depicted as merely subsistence systems (SEDES/INSEE, 1966; Eddy, 1979; White and Meadows, 1981; Sempeho, 1985; Gryseels, 1988; Danckwerts, n. d.). Animal traction, for example, accounts for about 40% of the gross value of food and non-food outputs of cattle, beef accounts for about 35%, milk for about 20% and manure for about 5% (S. Sandford, ILCA, Addis Ababa, Ethiopia, personal communication).

## Performance

**Cattle.** African cattle can be classed into four major types: the fairly large North Sudan Zebu, the Small East African Zebu, the Sanga of the south and the taurine breeds in West and central Africa (Epstein, 1971). These populations were selected for their multipurpose performance and ability to cope with environmental stress. When raised under extensive management with few external inputs, their performance is characterised by slow juvenile growth, late sexual maturity, long calving intervals and generally modest milk yields (Wilson, 1983; Trail, 1985; de Leeuw, 1986; Otchere, 1986; Wagenaar et al, 1986).

Breed differences seem to be less important for the productivity of African cattle than environmental and management influences. Major production constraints are associated with management and husbandry, the nutrition × disease complex and the seasonality of feed availability, especially in the traditional system with communal grazing. A comparison of all outputs from cattle in Botswana's traditional system and calf weight only from ranches showed that the traditional system is almost twice as productive in liveweight equivalents (9.91 kg/ha/year) as ranching (5.01 kg/ha/year) (de Ridder and Wagenaar, 1984).

**Sheep.** These are classed into four main types: the small, thin-tailed hair sheep of West and central Africa, the large, thin-tailed hair sheep in the Sahel, the fat-rumped Somali sheep and the fat-tailed hair sheep of East and southern Africa (Ryder, 1984).

Because of the long-term adaptation of sheep to specific environments, their performance matches production conditions. Most sheep in sub-Saharan Africa are aseasonal breeders, and some are also highly fecund. Overall productivity per ewe is largely determined by natural production conditions, but even under unfavourable conditions sheep are more productive on the basis of body weight than cattle (Wilson, 1982; Armbruster, 1987).

The major constraint on sheep productivity is high reproductive wastage (up to 40%) which greatly reduces selection possibilities. More frequent lambing and lower mortality thus need to be emphasised, while increased litter size and growth rate are of lesser importance (Peacock, 1985; Armbruster, 1987).

Management practices strongly influence sheep performance, the differences between flocks exceeding 200% (Peacock, 1987). Reduced performance is often due to a combination of nutrition and disease/ parasite problems which could be tackled through better management. Therefore, a careful analysis of management practices under all production circumstances is desirable.

## PERFORMANCE TESTING

### Needs and objectives

Performance testing is a goal-oriented, systematic process of collecting and analysing data on economically important performance traits and management practices under defined production conditions. The objectives of performance testing are to:

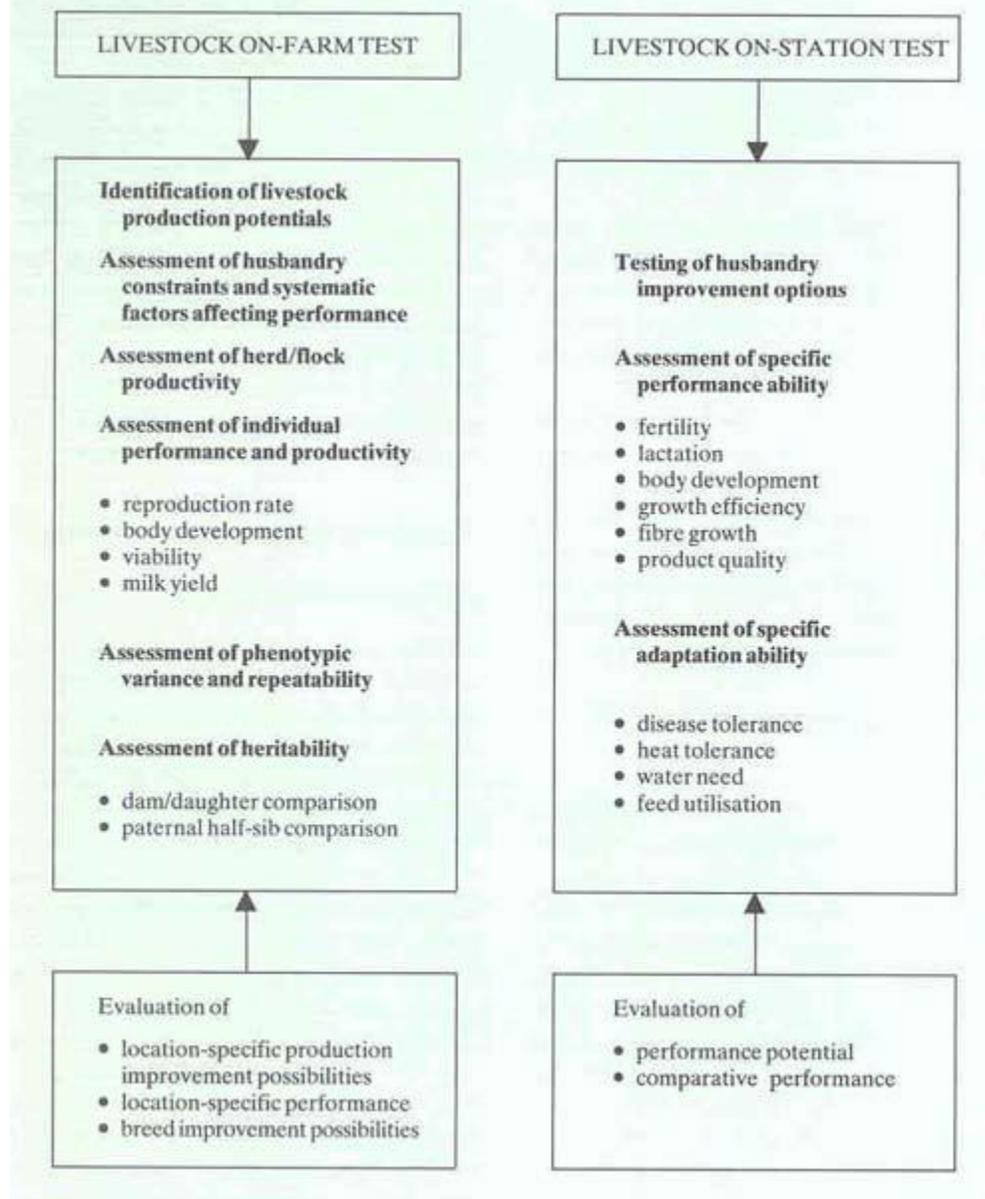
- identify and quantify non-genetic constraints to animal performance in order to improve husbandry, hygiene and feeding,
- facilitate the economic evaluation of the production process and of technical interventions,
- characterise and assess breed performances under defined production conditions,
- contribute to breed improvement through objective selection of breeding stock.

Performance testing is useful and justified only if results are made available to those engaged in livestock breeding and development, i.e. farmers, extension agents, researchers and policy makers.

### Approaches to performance testing

The significant long-term effects of management on animal performance, and the immediate impact of improved husbandry, hygiene and feeding, underline the need for on-farm testing. Collecting information on animal performance on the farm makes it possible to identify production prospects, as well as different management variables and their effects on the production process. It is also helpful in identifying problem areas needing more in-depth assessment of cause-effect relationships and production aspects in which improvements can be made (Figure 1).

**Figure 1.** Complementarity of on-farm and on-station testing.



Data on individual reproduction and production traits are required to assess herd/flock productivity and phenotypic variation of traits. However, genetic parameters can only be estimated under controlled breeding, which is difficult to implement on farms because of the small size of farm flocks/herds and mixed herding on communal pastures.

On-farm performance testing provides information on location-specific production conditions and location-specific performance of individual animals or breeds, as well as on breed improvement options appropriate to particular systems. Breed comparisons and assessment of specific performance abilities are essential for evaluating the relative merits of breeds, but these tests are unlikely to be implemented on the farm because they require many animals of several breeds over several years to assess production potential in a single environment.

These conditions are fulfilled in complementary livestock on-station tests, as was demonstrated by the classical beef-cattle breed comparisons implemented in Botswana and Zimbabwe (APRU, 1986; Tawonezwi, 1987; Ward, 1987). On-station trials are required to assess responses of animals to improved management and feeding. However, their accuracy, and hence their relevance to subsequent on-farm performance recording, is usually influenced by genotype x environment interactions.

## Trends in performance testing

### Past performance testing

A comprehensive review of cattle breed studies in Africa by Trail (1981) listed 500 papers published between 1949 and 1978. Of these, only 20% gave comparative information on two or more breeds and only 5% included information which allowed breed comparisons based on productivity indices. The majority of the papers (56%) related to indigenous cattle breeds, 30% were on crossbreeds and 14% on exotic breeds. Growth was measured in 72% of the papers, reproductive performance in 41%, milk production in 33% and viability in only 18% of the papers. The review did not cover management x animal performance interactions, but there is considerable evidence that one of the most important objectives of performance testing – improved management and production efficiency – received little attention in early testing activities.

Searches on ILCA's in-house database, the FAO Agricultural Information System (AGRIS) and the database of the Commonwealth Agricultural Bureaux International (CABI) identified references to a further 139 studies of on-farm and on-station performance testing of cattle and small ruminants carried out in sub-Saharan Africa between 1978 and 1987 (see Separate Bibliography).

As expected, the number of references found reflected the relative sizes of regional livestock populations: the most numerous were references from East and southern Africa, followed by references from West and central Africa. Predictably, references to cattle (85) outnumbered those to small ruminants (54). For both cattle and small ruminants, on-station testing (47 and 33 studies, respectively) was reported more frequently than on-farm testing (38 and 21 studies).

On-station studies were mainly experimental, while on-farm studies were predominantly diagnostic, aimed at assessing non-genetic constraints to production but often covering only a limited number of factors. Health status was seldom recorded on-station; when it was recorded on-farm, it was not evaluated in relation to performance. More than half of the reports were short-term studies during which it is not possible to assess reproductive performance and viability, nor, for that matter, to evaluate animal productivity and the relative importance of its components.

**Objectives.** The principal objectives of performance recording on stations and on farms were different and depended on the duration of the study. Short-term experimental and diagnostic studies on stations and all diagnostic testing programmes on farms were aimed at assessing non-genetic factors (excluding disease) and their effects on performance. Genetic factors generally received little attention. This contrasted with the majority of medium- and long-term on-station experiments which were mainly concerned with breed evaluation and related genetic research.

The objective of most on-farm studies was systems analysis to identify non-genetic husbandry constraints; only a small proportion investigated possibilities for genetic improvement. Data on genetic improvement usually came from large-scale commercial farms. Two long-term on-station/ on-ranch breed performance comparisons specifically highlighted the need to evaluate indigenous breeds before embarking on crossbreeding programmes. One of them was done in Zimbabwe, and compared the indigenous Tuli, Nkone and Mashona breeds with Africander, Brahman, Sussex and Charolais cattle (Ward, 1987). The other was done in Botswana by the Animal Production Research Unit and compared the local Tuli and Tswana breeds with Africander (Buck et al, 1982). Both studies indicated the outstanding overall performance of indigenous breeds in beef production.

**Implementation.** On-station studies were usually financed and executed by the relevant ministries of national governments, with occasional assistance from donor agencies. National governments were also the main source of reports on short- and medium-term studies.

Most long-term studies on-station involved international agencies, such as the International Livestock Centre for Africa (ILCA). The Centre has been a major executing agency for long-term systems studies published in the 1980s, which reflect the change in emphasis from on-station performance testing to on-farm research, stimulated principally by collaborating agencies.

**Relevance to production systems.** On-station production systems described in the literature invariably include husbandry methods which are not used in the traditional system, such as routine disease control, exotic breeds, restricted breeding season, planted forages and fencing. The experimental results were therefore more relevant to commercial farms than to the predominant traditional sector. Moreover, because of administrative constraints, on-station performance was often below expected levels.

Awareness of the need to direct research towards the prevailing production systems has increased during the past 10 years, with the result that studies now include a diagnostic stage to identify the complex factors influencing output, which is then followed by component research. The increasing number of reports describing livestock performance on farms is a direct result of this change. True on-farm performance recording has been focused on non-genetic factors, but methodologies are being developed to facilitate research on genetic improvement in production systems with small flocks and herds.

### **Current performance recording**

Performance recording is currently being undertaken throughout sub-Saharan Africa, but small ruminant programmes, particularly those implemented on farms, are more common in West Africa, and cattle programmes are more frequent in East and southern Africa (Table 2). Most on-station work is funded and executed by national governments, whereas the majority of on-farm programmes have external participation and/or funding. Most countries have on-station comparisons of breed and crossbreed performances, and generally there are concurrent selection programmes based on the performance testing of a major local breed or breeds.

**Table 2.** Current programmes for on- farm and on-station performance recording.

	Small ruminants		Cattle	
	On-farm	On-station	On-farm	On-station
West Africa				
Benin	D+M+G*	?	?	?
Burkina Faso	D	?	?	?
Côte d'Ivoire	D+M+G*	GS	D+M*	GB+GS
Mali	D+M*	?	?	?
Niger	–	GS	?	GB+GS
Nigeria	?	GB+GS	?	GB+?
Senegal	D+M*	GB+GS	?	?+GS
Togo	D+M+G*	GB+GS*	?	?
The Gambia	?	?	D+M*	GS*
Central Africa				
Burundi	D+M+G*	GB+GS*	?	?
Cameroon	?	GB	?	GB+GS
Congo	D*	GS*	?	?
Gabon	?	?	?	GB+GS
Rwanda	?	GB+GS	?	GB+GS
Zaire	?	?	D+M+G*	?
East Africa				
Ethiopia	D+M*	GB+GS*	D*+?	GB+GS
Kenya	D+M+G*	GB+GS*	M+G	GB+GS
Somalia	D*	?	?	?
Tanzania	?	?	D+M+G	GB+GS
Southern Africa				
Botswana	D+M*	GB	D+M+G*	GB+GS
Madagascar	?	?	D+M+G*	GB+GS
Malawi	?	?	D+M+G	GB+?
Mozambique	D	GB	M+G	GB+GS

**Notes:** An asterisk (\*) indicates external agency participation and/or funding. Question mark (?) indicates a possibility that the particular research was done but was not reported in literature. Dash (-) means that the research was not carried out. D = diagnosis of technical constraints on farms; M = testing/monitoring of management improvements on farms; G = testing/monitoring of genetic improvement on farms; GB = breed comparison on stations; GS = within-breed selection on stations.

**Target production systems.** The target production system for on-farm performance recording is small-scale, mixed crop-livestock farming. There are two exceptions to this. One is the recording of small ruminant performance and health in the pastoral system of Somalia, which

has been undertaken jointly by the Somalian Government, ILCA and GTZ since 1983 in 200 meat-producing flocks of mixed species. The other is cattle performance recording in countries, such as Kenya and Zimbabwe, which have large-scale beef or dual-purpose (milk and meat) production on ranches and in specialised dairies.

On-farm recording in national beef and dairy schemes is organised as in the developed countries. Daily records of reproductive events, milk yield and/or liveweight are kept by the farmer and these are checked monthly by staff of the coordinating institution. The main objectives of such programmes are to select replacement sires and heifers and to monitor husbandry practices. Contract matings are used to produce artificial insemination bulls.

**Phases and their duration.** The first phase of performance recording is *diagnostic*, usually lasting 2 to 3 years. Well established programmes subsequently include *on-station intervention testing* of 3 to 4 years, during which *on farm testing* of husbandry, hygiene and breeding interventions is already generally possible. On-farm testing is also backed by breed improvement programmes.

Development projects designed to introduce small-scale dairy units (e.g. in Kenya, Tanzania and Botswana) may have a reduced diagnostic phase. Interventions are tested on-station early in the programme and are released for on-farm testing when proven, which may take between 1 and 5 years. Established technologies can be transferred from other systems in similar locations at the beginning of the project. In dairy development projects, on-farm recording serves primarily the objectives of monitoring and improving management, hygiene and breeding practices. It also serves as a basis for assessing the economic efficiency of the improved livestock production subsystem and its integration into the mixed farming system.

### **Strategic research in collaborative networks**

The preceding examples demonstrated the use of on-farm performance recording to improve location-specific livestock production systems. Other on-farm recording programmes, such as those carried out in Côte d'Ivoire, Ethiopia, Gabon, Gambia and Zaire, contribute to strategic research on animal health and production in the tsetse-infested areas of Africa. Performance recording on farms also plays a significant role in the work of the African Trypanotolerant Livestock Network which brings together scientists from national agricultural research systems (NARS) and from ILCA and the International Laboratory for Research on Animal Diseases (ILRAD) to study the complex interactions which influence trypanosomiasis and its effects on livestock performance.

The research coordinated by the network covers all the major aspects of trypanosomiasis and its control, but focuses on the use of trypanotolerant livestock. Data on tsetse parameters and animal health and production are collected monthly at various network sites, using standard techniques and procedures. These data are analysed monthly, using centralised data processing complemented by on-site computing facilities. The network's coordinating office in Nairobi is staffed by ILCA and ILRAD, and gives technical support to the national programmes through training courses, field supervision and data processing and interpretation. Progress made is assessed at periodic meetings of network collaborators, and on the basis of this assessment, protocols are modified and future research and development programmes are planned (ILCA, 1986; 1987).

The African Trypanotolerant Livestock Network is not the only collaborative research network active in sub-Saharan Africa. There are now others, such as the Small Ruminant Research Network which has collaborative programmes in Congo, Côte d'Ivoire, Ethiopia, Kenya, Mali, Somalia and Togo, and whose objective is to carry out strategic research on small ruminants in such key areas as the economics of production, breed evaluation and improvement, feeding systems, reproductive wastage, and management. Other collaborative research networks being developed by NARS in sub-Saharan Africa are the Cattle Research Network and the Animal Traction Network. As a result of these developments, on-farm recording is expected to expand rapidly in the next 5 years.

## FUTURE PROSPECTS

**Complementarity of on-farm and on-station testing.** Collecting, analysing and using data on technical, economic, biological and genetic parameters is the basis for improving livestock production in Africa. The information available at present is not sufficient to guide system improvement and breeding, despite the positive trend towards system-oriented, on-farm performance testing. On-farm testing programmes are difficult to implement in Africa due to infrastructural problems, lack of funds and constraints linked to the production system (Table 3). In addition, the numerous management structures, practices and skills observed in smallholder and agropastoralist systems greatly increase the number of covariates to be incorporated in the model, and this impairs continuous data recording.

**Table 3.** Constraints to on-farm testing of livestock performance.

Factor	Problem	Solution
Representative sample of households and animals	Covariate distribution (environment, systems, livestock production pattern)	Conduct baseline survey for sample collection
Ownership of animals	Consent to participate	Provide information on objectives of testing and feedback
Owner attitude	Identification of animals	Provide information on objectives of testing and feedback
Animal mobility	Locating herds for performance measurement	Monitor performance frequently and provide feedback
Length of production cycle	Risk of losing animals; effect of covariates	Use large sample size; estimate correction factors
Asynchronous production	Aseasonal breeding	Monitor traits at regular intervals
Management viability	Factors affecting performance	Select sufficiently large representative sample to monitor management pattern
Communal grazing	Mating structure; information on parentage	Identify paternal half-sib groups (blood grouping)
Multiple output	Multipurpose breeds	Measure different traits; assess economic importance; assign biological and economic weightings to individual outputs
Small herd/flock size	Confounded farm and animal effects (if <2 animals/class/farm);	Exclude single-animal farms; correct for farm effects; synchronise production; use

	difficult simultaneous comparisons	grouped herd/flock comparisons
Single-sire herd/flock	Confounded sire and flock/herd effects	Use different sires or artificial-insemination group- breeding schemes

Under these circumstances, success can only be guaranteed by using large stratified samples, regular data collection and efficient data handling to give immediate feedback. Multiple outputs and small herd/flock structures constrain breed performance characterisation and evaluation and reduce the impact of genetic improvement schemes.

On-station testing (as outlined in Figure 1) can only be beneficial if on-station management practices simulate those used on the farms. Similarly, livestock on-farm testing schemes should be complemented by on-station programmes which conform with the ecological environment and management practices prevailing in the field.

**Genetic improvement.** Genetic improvement schemes must have a field base to be successful. Because of single-sire flocks/ herds, communal grazing and small herd/ flock sizes in the smallholder systems, group breeding schemes with open, nucleus breeding units on stations may continue to predominate in sub-Saharan Africa. Such units must be supported by effective dissemination of the selected improved stock, and of superior sires bred through artificial insemination.

On-station breeding units also may provide the centre for initial gene introduction and for rapid distribution of superior genotypes through multiple-ovulation-embryo-transfer (MOET) schemes, which, as Smith (1988) states, area model for the role of sophisticated technology in improving indigenous breeds and developing production systems. MOET schemes can achieve immediate improvement through selection of foundation animals and attain faster and more effective performance improvement rates, while being able to test for traits difficult to record in the field, such as disease tolerance and feed conversion efficiency.

**Data management.** Developments in computing are facilitating the handling of performance data and associated information collected in farming systems research and development programmes. Most African countries now have on-site facilities for data entry and preliminary analysis; final analyses and interpretation may, however, need to be done centrally.

Despite advances in computer technology, the lack of effective mechanisms for analysis and feedback of results and recommendations to farmers, researchers and extension agents, remains a major constraint to livestock development in sub-Saharan Africa. The objectives of performance testing can only be achieved if the collected data can be quickly analysed and interpreted and recommendations made and implemented promptly. And only then can farmers, researchers and extension agents collaborate effectively.

To facilitate this process, ILCA has developed a data entry analysis system called IDEAS, which has been distributed to more than 50 research sites in sub-Saharan Africa. IDEAS incorporates both a standardised performance recording system and an analysis system for herd management decisions, and it can interface with software for other analyses that may be required.

The importance of efficient data management and rapid feedback of results cannot be overemphasised, particularly in on-farm testing programmes. These programmes offer the

possibility of effectively integrating microcomputer technology and appropriate software in livestock performance testing, thereby overcoming some of the major difficulties experienced in the past with handling field data and providing feedback.

**Organisation of standardised testing.** The impact of on-farm testing schemes will be measured in terms of their ability to improve livestock management and productivity. Plasse's (1982) management prerequisites to ensure successful testing programmes are rarely fulfilled under African conditions; rather, most management aspects are part of a complex exercise requiring a systems approach to performance testing if improvement possibilities are to be fully understood.

The systems approach in performance recording combines data on the farm environment (markets, services etc) with those on farm subsystems and on herds/ flocks. It requires a standardised recording approach, a predetermined data recording structure, and an efficient data handling and analysis system. Assigning the development, implementation and analysis of these tasks to collaborative research networks may speed progress, avoid duplication and attract additional funds for on-farm performance testing.

## CONCLUSION

About 75% of Africa's livestock are in smallholder farming systems, where they fulfil several functions and are a major source of cash income. Livestock performance can be increased through improved management and output specialisation. However, the production problems identified and the improved technologies proposed must be relevant to the prevailing production system. On-farm comparative breed evaluation, as well as assessment of specific performance ability and technology development, can be complemented by on-station performance testing.

During the last decade, on-farm performance testing was expanded considerably, but on-station programmes were more widely reported. Most of the on-farm tests reported in literature were short-term studies which could not assess the whole production process and often did not match health and management data with performance.

Although on-station breed comparisons are valuable, their application is limited by high costs and genotype  $\times$  environment interactions. These problems can be overcome by widespread on-farm testing within collaborative networks, based on standardised methods and enabling rapid data handling and feedback of results. Complementary on-farm and on-station performance testing organised within networks could also support genetic improvement programmes.

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