Centre Technique de Coopération Agricole et Rurale ACP-UE
Technical Centre for Agricultural and Rural Cooperation ACP-EU
CTA

Strengthening biometry and statistics in agricultural research

Summary report and recommendations of a CTA/University of Hohenheim workshop

Hohenheim, Germany, 7–9 October 1996

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Technical Centre for Agricultural and Rural Cooperation
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Technical Centre for Agricultural and Rural Cooperation (CTA) was established in 1983 under the Lomé Convention between the African, Caribbean and Pacific (ACP) States and the European Union Member States.

CTA's tasks are to develop and provide services that improve access to information for agricultural and rural development, and to strengthen the capacity of ACP countries to produce, acquire, exchange and utilise information in these areas. CTA's programmes are organised around three principal themes: strengthening facilities at ACP information centres, promoting contact and exchange of experience among CTA's partners and providing information on demand.

Acknowledgements

This Summary Report has been prepared by Janet Riley, Head of the Overseas Biometrics Unit at IACR-Rothamsted, UK. Dr. Riley has worked extensively in developing countries for a large number of donor agencies as a consultant in biometric design and analysis, as an adviser on multidisciplinary project design and progress, and as a trainer in biometric and computing methodologies.

Rothamsted Experimental Station is part of the UK's Institute of Arable Crops Research and is the oldest agricultural research station in the world. Many eminent statisticians have worked there, continuing the work initiated by R.A. Fisher and F. Yates. The institute is grant aided by the Biotechnology and Biological Sciences Research Council of the United Kingdom.

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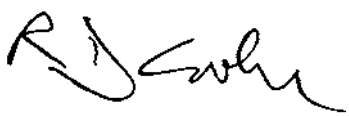
Foreword

Weaknesses in the application of biometry and statistical methods frequently detract from the quality of agricultural research programmes. These weaknesses in turn reduce the impact of such research and thus the prospects for continued funding. Consequently, CTA decided to undertake a study to identify the priorities regarding the effective utilisation of biometry in agricultural research in ACP countries; to develop appropriate strategies for increasing awareness of the problems; and to develop guidelines for actions that can be taken to address these problems such as publication activities, training programmes, and networking between organisations.

An important element of the study was a workshop organised by CTA in collaboration with the University of Hohenheim, Germany, and held at the University from 7 to 9 October 1996. Workshop participants analysed the results of the first phases of the study and offered suggestions for follow-up phases. They were able to contribute their experiences as biometricians and researchers and acknowledged that to improve the quality of agricultural research they had to work more effectively together.

The recommendations summarised in this report require attention by the scientific, academic and donor communities, and are to be refined in the follow-up phases of the study.



Dr R D Cooke

Director, CTA

Introduction

1. Recognising that weakness in biometrical methods often leads to difficulties in obtaining funds for research projects and for later publishing activities, the Technical Centre for Agricultural and Rural Cooperation funded a study on "Strengthening Biometry and Statistics in Agricultural Research" to examine the problems of biometric skills and facilities in the ACP countries and the impact of these upon agricultural research.

2. The project consisted of five phases, to obtain information and present results and was commissioned to two consultants with extensive experience of biometrics in the developing world. The aims of the study were:

- to determine the problems, at which levels and where (in which countries, areas) the problems occur, where similar problems have been resolved, where they did not occur, and why
- to propose appropriate strategies for increasing awareness and understanding of the problems
- to identify and define needs with respect to effective utilisation of biometry in agricultural research in the ACP countries. The specific needs of the users (mainly agricultural researchers) and of the biometricians themselves should be taken into account
- to develop guidelines that can be taken to address the problem (publications, training, networking, etc.)

3. A midproject workshop was held to exchange information and to establish results to date.

4. The workshop was attended by more than thirty invited representatives from twenty-two African, Caribbean and Pacific countries, as well as representatives of international organisations European institutions and donor agencies.

5. The workshop centred around the presentation of the consultants' findings to date based upon individual investigations and a large-scale survey of more than 500 scientists and biometricians throughout the ACP countries. Nine further presentations were made by representatives of the ACP countries to address specific problems and opinions. Twelve discussion groups addressed the issues raised and summarised concluding points.

6. During the presentations and discussions, some major points were identified clarifying problems and outlining actions for amelioration. These can be summarised as follows:

6.1. Availability of professional biometricians in national agricultural institutes and universities in the ACP countries is poor. The number of posts for biometricians is in decline, and funding cuts lead increasingly to their substitution with inadequately trained staff or statistical computer software.

6.2. The quality of biometric training in the ACP countries for professional biometricians and for agricultural scientists does not incorporate modern biometric methods and powerful, accurate computing exposure. Biometric training in developed countries is

considered to be complex, mathematical and insufficiently linked to real agricultural problems in the developing world.

6.3. Statistical computing facilities and books and journals for biometric methodology are lacking in availability; existing documentation is mathematical and not focused on relevant biometric problems. Statistical computer software is expensive and inadequate in content; associated documentation is complex and discourages use.

6.4. Institutional structures discourage both professional development of biometricians and their collaborative inputs to all stages of planning, conduct and assessment of multidisciplinary agricultural studies. Isolation from other biometricians and inadequate availability of electronic networks results in poor information exchange and no appreciable development of professional skills.

6.5. Donors, policy makers and managerial staff are insufficiently aware of the financial savings which can be made by incorporating biometrics in agricultural projects. **A** greater awareness of biometric skills and their value and impact needs to be encouraged within the donor community.

6.6. The lack of a professional biometric input to agricultural research and development projects has strong implications for the quality of project results and the poor rate of acceptance of publications in international agricultural journals.

6.7. Systems and funds are required within the national agricultural institutes to create and maintain professional biometrics posts, to ensure greater collaboration between biometricians and scientists at all stages of research, to develop greater acknowledgement of professional biometric skills and to provide biometricians with in-service training in recent biometric and computing methodologies.

6.8. University syllabuses for biometric training in both developing and developed countries need to be restructured with a two-level approach, for agricultural scientists and for biometricians separately with a strong practical component relevant to developing countries agricultural problems and support from modem, accurate statistical computing.

6.9. **A** strong practical element of biometrical and computing training must be incorporated in training courses in farming systems.

6.10. Statistical software requires close assessment for its relevance to agricultural research, accuracy and cost. This information must be made available to donors, institutes and project managers to ensure that the most suitable and cost-effective software is available for both professional biometricians and scientific staff.

6.11. Biometric books and journals need to be less mathematical, incorporate modern biometrical and computing methods and be more practically orientated towards a multidisciplinary farming systems approach relevant to developing countries agriculture.

6.12. Publishers of international agricultural journals should include professional biometric expertise on editorial boards and in the manuscript review process.

6.13. Biometricians in the ACP countries should promote their skills more actively, encourage scientists, management and donors to acknowledge their professional role.

The creation of networks, electronic or otherwise will alleviate problems of isolation and form a strong nucleus upon which a greater professional force can be built.

7. **A** detailed workshop Proceedings will be published. This summary report contains a statement of problems and recommendations made by the workshop participants considered to be largely influential to the issue and requiring further attention by the scientific, academic and donor communities.

Strengthening biometry and statistics in agricultural research

A. Agricultural research efficiency

1. Agricultural and biometrical synergy

1.1. Sustainable agriculture projects and programmes contribute to world development by improving agricultural productivity and increasing the welfare of the poor whilst reducing negative environmental impact. Issues of global change to the climate, population dynamics and political perspectives have resulted in new development policies to reflect changing technological and economic needs.

1.2. Traditional agricultural research approaches involve detailed biophysical studies of individual plant or tree species or livestock breeds, these studies being done in controlled conditions on research stations. Emphasis has changed from this primary research to broader but less precisely controlled studies and surveys to assess environmental changes and the effects of technology interventions upon the natural environment and the population at large.

1.3. Methodologies for natural resources research must now involve a holistic approach to the study of agricultural systems, and the assessment of impact of technology changes to components of systems upon farmers, their incomes, their wellbeing and lifestyles.

1.4. The design of agricultural studies is necessarily more complex: the whole research spectrum needs to be addressed from basic laboratory and station research through adaptive and applied research on farms and within communities to farmer impact assessment. Research at each of these stages can benefit from the rigour introduced by clear planning, appropriate information collection, information summary and interpretation and its presentation in appropriate formats to all involved stakeholders.

1.5. When applied agricultural research is done on-farm, farmers must cooperate in studies which are long-term and possibly demanding of their own resources. The choice of farms to include in the study must be judged with care: farms differ to the extent that homogeneity cannot be realised and sufficient farms will be needed to ensure that representative results can be achieved throughout the study.

1.6. The size of studies must be large to allow for variability introduced by less controlled conditions. The studies must be lengthy to allow sustainability issues to be determined. Experiments on-farm tend more to the size of full surveys with large quantities of data. **As** costs of experimentation, survey or impact assessment study can be prohibitive, the collection of excessive data must be avoided yet enough data must be collected to ensure the cost-effectiveness of the study and guarantee that scarce research funds are not wasted.

1.7. The extent to which the farmer is involved in agricultural studies varies according to study objectives. The balance between farmer and researcher input can be classified:

- the farmer lends land and the researcher does the study
- the researcher plans the study but the farmer does the study

- the farmer plans the study, or modifies usual practice, and the researcher observes
- the researcher plans the study on research station land but the farmer contributes suggestions for planning and comments on outcomes

1.8. The underlying logic to the design of all agricultural studies and surveys is provided by a biometric input. This cross-cutting discipline relates the objective-setting exercise to the design stages and ensures that adequate useful data can be generated and analysed efficiently to allow reliable recommendations to be formulated.

1.9. Whatever the degree of farmer participation, study design rarely follows standard textbook structures and a range of design skills are necessary to produce designs which will be the foundation for representative data generation.

1.10. Data collected from farmer participatory and impact assessment studies may be numerical, but nonnumerical data are important to reflect farmer opinions, preferences and judgements of technology changes. Such qualitative data are crucial to the full understanding of the impact of technology change upon lifestyles within communities. Numerical measurements of improved crop yield or animal weight gain are of little importance if the technology change which brought those improvements results in the need for greater labour.

1.11. Analyses are necessarily more complex and their interpretation requires a strong biometric understanding. Methods for summary of qualitative data to achieve unbiased recommendations are available. Knowledge of these methods is essential.

1.12. Biometric skills have traditionally been taught to deal with straightforward studies such as those for single-species on controlled research stations. Yet biometric needs for farmer participatory and impact assessment studies are greater, to cope with the informality of designs, large variability in data and variety of data types. To maintain rigour a strong biometric input is essential, an input consisting of powerful, flexible methods. These are available, particularly with the fast development of computer power, but knowledge of these to agricultural researchers is limited and training in their use is rare.

1.13. Biometric skills in **ACP** countries are inadequate to support the changing priorities of agricultural research with the consequence that research quality is poor. This inadequacy is based upon:

- the low ratio of biometricians to scientists in **NARS** institutes
- the decline in numbers of biometricians in national institutes in recent years
- the availability of biometric training courses in national universities and NARS institutes
- the limited biometrical knowledge and skills of available biometricians
- the availability of, and low skill rate with, statistical computer software
- the low acceptance rate of scientific publications, rejection based upon inadequate biometrical design, sampling procedures, analysis and interpretation.

1.14. Failure to improve biometric skills in the ACP countries will result in a decline in research quality, the generation of nonrepresentative research results, the rejection of publication of research results and their exclusion from the research debate. This will be to the detriment of global development and natural resources conservation and sustainability.

2. Factors contributing to biometric quality in agricultural research

A number of factors contribute to the decline in biometric skills and facilities in the ACP countries and its consequences for agricultural research efficiency and cost-effectiveness. These relate to the biometric skills of professional biometricians, the biometric skills of scientific research staff, the strength of perception of biometrics as a professional discipline by the donor community and government departments, and institutional structure within universities and national agricultural institutes.

2.1. Biometric skills and facilities of professional biometricians in national agricultural institutes and universities are not keeping pace with changing research demands. The factors relating to this are:

2.1.1. The availability of professional biometricians is poor. Estimates of the biometrician:scientist ratio in the Caribbean are 1:40 and in Africa 1:78. These figures are heavily weighted by the numbers of professional biometricians in international centres. The ratios in the national institutes are worse.

2.1.2. Funding reductions in agricultural research are often reflected in immediate loss of biometrician posts under the mistaken belief that biometrics skills can be replaced by the use of statistical computer software.

2.1.3. In-country biometrics training courses do not keep pace with modern biometrical and computing developments. Courses in developed countries are often perceived to be too mathematical or not appropriate to the biometric problems of the student's country or institute.

2.1.4. Where professional biometrics posts exist, the biometrician works in isolation from other biometricians and professional stimulation is poor.

2.1.5. Training awards for biometricians often provide for study at PhD level in developed countries. This commonly leads to a mathematical thesis, lack of interest in practical biometric problems and a qualification which may offer lucrative employment in a sphere other than agriculture.

2.1.6. The availability of modern, relevant biometric facilities such as computers, biometric journals and books is inadequate. Access to computer networks for literature searching and communication is limited within the ACP regions.

2.1.7. Statistical software availability is limited by cost. Donated or pirated software are not supported by appropriate documentation or training. Much commercially available statistical software is technically inadequate or faulty. The contribution of such

statistical software to the biometric skills of national agricultural institutes and universities is therefore minimal.

2.1.8. Biometric research papers from these institutions are often rejected for publication in international journals because they do not incorporate relevant, modern biometrical methodology and because publishing styles and language are not adhered to. Biometricians thus become discouraged from this form of professional interaction and any further attempt to raise their own profiles in this way in the biometric world are avoided.

The strengths of professional biometricians, when available in the national institutes and universities, are inadequate to underpin scientific research activities with the consequence that both biometric and scientific publication is poor and declining in quality.

2.2. Biometric skills of scientific research staff are inadequate to support the rigour required in internationally recognised scientific research. Factors influencing this are:

2.2.1. Mathematical training in schools involves a repetitive learning approach rather than the development of an understanding of data features and patterns with the result that scientists required to use statistics lack confidence in any exploratory data-handling skills.

2.2.2. University training courses in biometrics, whether in developed or developing countries, are perceived as being too mathematical, involving the learning of a rigid formulaic approach to statistical analysis and not incorporating a practical computer-based syllabus relating directly to multidisciplinary studies in the field.

2.2.3. In-service biometric training courses are often too short, restricted in application and have little impact and lasting value unless supported by longer term collaborative work with course presenters.

2.2.4. In multidisciplinary research, many team members may be social scientist or extension workers. Their basic training not statistical and their research contributions will not therefore incorporate a biometrical viewpoint.

2.2.5. Nonavailability of professional biometricians results in their replacement by nonstatisticians, whose biometrical experience may be no more than the completion of a computer course or a statistics course.

2.2.6. Awareness among the scientific community of the value of biometrics is minimal due to a distrust of the subject engendered during inadequate training programmes. Relationships between scientists and professional biometricians suffer from this distrust and unless biometricians take steps to dispel this the gulf between the two professions will not be bridged.

2.2.7. Abundance of poor software provides inadequate tools for the application of sound and appropriate biometric methodology. Biometric software and documentation are complex, mathematically based, and discourage nonstatistical users from efficient handling of scientific data.

2.2.8. Journal demands in terms of biometric standards are inconsistent and thus discouraging. Referees and editors often demand statistical usage which contradicts good statistical practice.

These factors contribute greatly to the level of research quality apparent in institute reports and national journals and the low level of international publication.

2.3. The strength of perception amongst donors and policy makers of biometrics as a professional discipline is declining. This is related to the following:

2.3.1. Many donors and policy makers do not relate the value of biometrics to efficiency and cost-effectiveness of agricultural research. This can be seen by the number of professional biometricians employed on developing country aid projects and by the frequent lack of inclusion of a biometrician on project assessment teams.

2.3.2. Much donor interest lies in impact assessment and cost-effectiveness of research. Whilst a mathematical and statistical input can offer much to the methods employed, economic and socially orientated approaches are usually employed.

2.3.3. Many donors do not appreciate the need for a different approach to biometrics for on-farm research as opposed to on-station research with its easily constructed textbook designs.

2.3.4. Computers and software are often donated as a cheap replacement for trained biometrical staff.

2.3.5. Donor agencies and national government departments are multistructured with staff having frequent mobility to different departments or projects. Continuity of support for biometric inputs and projects is difficult to maintain.

2.3.6. Few donor agencies demand that biometric input is a prerequisite to the achievement of aid funds for agricultural research. Those making this demand do not have infallible mechanisms to ensure that the input is of good quality and continuous.

2.3.7. There are no clearly identified sources of donor funds for pure biometrics research.

2.4. Institutional structure in national institutes and universities is not conducive to the development of the biometric profession:

2.4.1. Because of funding shortages, universities are reducing the amount of time spent on biometric teaching.

2.4.2. Biometry is often taught using out-of-date syllabuses by nonbiometricians.

2.4.3. Funds are increasingly spent on human resources rather than research facilities and equipment.

2.4.4. Professional biometricians are few in number and therefore difficulties in recruitment are experienced.

2.4.5. Computer facilities are often stolen because of inadequate security measures.

2.4.6. Biometricians are often promoted to more senior administrative positions, their biometric post not being refilled,

2.4.7. In many institutions, biometricians are considered to have a service function, to analyse collected data rather than to contribute at all stages of a study as a professional scientific collaborator.

2.4.8. There is little encouragement for biometricians to do biometric research and to publish their results in the biometric literature.

2.4.9. A critical mass of biometricians, formed by locating staff together would strengthen the role and amount of advice that biometricians can offer. Because of the wide dispersion of institutes in developing countries, this grouping structure would result in fewer scientists having access to biometric skills. The inefficiency of currently available computer equipment and lack of electronic networks linked to many national institutes would support the location at this stage of biometricians in their own institutes.

B. Existing initiatives

A number of activities have been initiated with regard to the development of biometric skills in developing countries although it is impossible for them to address all areas and problems. These activities are recorded here.

1. CGIAR intercentre group training courses and networks

1.1. A number of the CGIAR centres have instigated intercentre group training courses in biometrics for biometricians and scientists from local **NARS** institutes. These involve teams of trainers from a number of the Centres, are practically orientated and concentrate upon crops and systems of direct relevance to the participants.

1.2. Electronic networks have been established to link biometricians in certain areas of the ACP regions. A network has been established in Eastern Africa, another in the Caribbean and Central America. A further network is being established amongst the French-speaking countries in West Africa. However, the participants are primarily those with access to computer facilities, this limitation excluding many from national institutes and universities who have no facilities.

2. Professional societies

2.1. The International Biometric Society has sponsored the formation of new groups of professionals in several regions of the world, including ACP regions, has donated journals and funded attendance at international conferences.

2.2. The International Statistical Institute and the Royal Statistical Society have active sections or committees dedicated to developing country interests and support requests for assistance where feasible.

C. Recommended steps

1. Professional biometric responsibilities

A number of direct actions by the biometrician will help to reverse the decline in use of biometric methodology and improve the quality of agricultural research.

1.1. The biometrician must be proactive, make the subject interesting and raise its profile as an interactive scientific discipline. The biometrician must aim to contribute to the work of as many scientists as possible, to raise awareness of the value of biometrics. The aim should be to demonstrate clear biometric methodology and its value, not create confusion with complex mathematical approaches.

1.2. The financial benefit of a biometrics contribution should be stressed by biometricians to donors and project managers at the project planning stage to demonstrate potential savings and impact upon scientific publication.

1.3. Biometricians must work within multidisciplinary teams and contribute biometric expertise on all of a project's components at all stages of the research spectrum from project conception to farmer impact.

1.4. Biometricians within the national agricultural centres and universities should forge links with staff of the **CGIAR** centres to encourage exchange of information and professional stimulation. Where networks exist, biometricians should request to join them even if they have no electronic facilities. The construction of such multitiered networks at an initial stage will be beneficial to information exchange and can be developed as computer facilities become more widely available. The impetus for these links must come from the national institutes but the **CGIAR** institutes must be prepared to respond to it.

1.5. If biometricians raise their own professional profile by collaborating in a broader sense, the value of biometric input will be more apparent and the development of a greater number of biometric posts will ensue.

2. Collaboration with donors and policy makers

2.1. Donors, programme managers, policy makers need to be made more aware of the managerial and financial benefits which can accrue from a professional and practical biometric input. This awareness can best be achieved through an international workshop to which these senior personnel are invited.

2.2. There is a need for policy makers and funding agencies to be targeted at all levels

and within all their departments to improve their awareness of biometric value and raise their interest in sponsoring biometric projects and biometric inputs to agricultural projects.

2.3. Funding agencies must encourage more solid use of biometrics within projects before contributing funds. Continuous assessment of adequate biometric input in projects needs to be determined by professional biometricians on behalf of the donors.

2.4. The CGIAR centres should be encouraged to strengthen their inputs and training schemes for national agricultural institutes and universities. In particular, ISNAR should be encouraged to support the strengthening role which biometrics can play in managerial and training issues in the national institutes and in strengthening project proposals.

2.5. Existing initiatives by professional statistical and biometric societies should be encouraged both for their financial contributions and their profile-raising activities for professional biometricians.

3. Reorientation of biometric training

3.1. Teaching of statistics needs to be addressed at several levels: in the school, at university and during employment. Training should not involve learning by rote, or the production of subjective significance tests, but should encourage the understanding of variability and methods for its estimation.

3.2. At university level and during employment, training courses need to be different for scientists and for biometricians. For scientists, a practical approach incorporating basic, modern statistical computing is needed with strong recourse to real problems in the field. For biometricians, a multidisciplinary approach acknowledging components of agricultural systems and their interrelationships should be stressed; support from training in sophisticated computer software to address complex multivariate datasets is essential. Training for biometricians needs to stress the need for their input to both research and development issues, and should incorporate agricultural material, consultancy techniques and report writing and presentational skills training.

3.3. Training courses need to be designed for extension workers and those with disciplines such as social sciences who traditionally have not received statistical training. This training needs to concentrate at a very practical level on the design of sampling procedures, data collection procedures to obtain representative data and simple summaries to display salient features.

3.4. Where possible, courses must be designed and presented by, or in conjunction with, local national biometricians. This will focus the training upon relevant problems.

3.5. Conference and meetings attendance can be considered as a valuable form of training. Funds for this should be sought by the individual biometricians.

3.6. Currently available training courses in biometrics require detailed assessment to

determine their suitability for the provision of practical biometric skills for a range of disciplines at all stages of the research spectrum.

3.1. Currently available training courses in farming systems need to be assessed for their adequate coverage of biometric and computing methodology.

4. Statistical computing issues

4.1. Software companies should be urged to modify statistical software to achieve the following:

- methodologies which are appropriate to practical biometric problems
- algorithms which are fault-free
- documentation which is more readily understood by nonstatisticians
- software which is affordable by developing country institutes

4.2. Encouragement by donors to supply computers and good statistical software to scientists and biometricians, with emphasis upon more powerful software for biometricians, will assist in the efficiency of application of biometrics to agricultural studies.

4.3. Currently available commercial software needs evaluation for its accuracy and suitability for agricultural research and development projects. Donors and institutes need to be made aware of the relevance of features of this software.

5. Biometric books and journals

5.1. Biometric books need to be written for a range of levels stressing less the mechanics of calculations, and more the practicalities of design, data collection and understanding of variability. Books need to address the farming system and its components and interrelationships. Books need to be prepared in different languages, in French, English and Portuguese for the ACP countries.

5.2. The prohibitive cost of books to developing country institutes needs to be addressed by publishers.

5.3. The donation by societies and developed country institutes of spare copies of biometric books and journals to schools, universities and institutes in developing countries should continue to be encouraged. Funding agencies should be requested to support the costs of delivery of this literature.

6. Strengthening of biometrics in scientific publications

6.1. National institutes and universities should encourage their staff to publish their work and to interact more fully with other institutions both nationally and internation-

ally to raise their professional interests and skills. **A** key issue in this area will be the strengthening of biometric inputs and presentation. Scientific writing courses should be made available to all scientific staff, including biometricians.

6.2. Internal review teams to monitor the quality of draft papers and reports in national institutes and universities are essential to raise standards. **A** biometrician should, whenever possible, be included on these teams.

6.3. Editorial boards of international and national journals should have a biometrician on the board or available to monitor submitted papers.

6.4. International journal publishers should be encouraged to reduce journal rates for national institutes and universities in developing countries so that journals are more easily obtained and publication encouraged.

7. Institutional changes

Whilst biometricians in the national institutes and universities aim to raise their professional profile amongst their scientific colleagues, support for this is required from institution management. Systems need to be developed to ensure that professional biometricians are recruited and that their work can progress in a professional manner.

The following recommendations support this aim:

7.1. Biometric posts should be filled with professional biometricians and not with theoretical statisticians or scientific staff with minor biometric qualifications.

7.2. Appointed biometricians should be recognised as having a profession, and should be accorded with the right and the wherewithal to develop their professional skills by doing biometric research, by attending biometric conferences and by having regular training to be aware of recent biometric and computing developments.

7.3. Research planning systems should be developed to ensure that biometricians are members of research planning committees, that they are consulted at all stages of research and development project plans, that project plans are not approved without agreement from a biometrician.

7.4. Biometricians should be acknowledged as joint authors of scientific documents to which they have contributed expertise, and should not be used as data processors.

7.5. Biometricians should be encouraged to attend scientific writing courses along with their scientific colleagues. When joint publications are prepared, the biometrician should contribute those sections relating to the biometric components of design, sampling, analysis and presentation to ensure that the biometric standards of the document are suitable for the intended journal.