IMPROVING RESEARCH METHODS ON BEAN BREEDING AT BURUNDI AGRONOMIC SCIENCES RESEARCH INSTITUTE

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Improving Research Methods on Bean Breeding at Burundi Agronomic Sciences Research Institute

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DECLARATION

This dissertation is my original work and has not been presented for a degree in any other University.

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DEDICATION

Dedicated to my late Parents CIRAMUNDA Lazare and NDABATEZE Anatholie,
my lovely Wife NTIRINGANIZA Jacqueline and my Sons
ITEKA Joy Thedy and INGABIRE Ken Nicky

Thank you all for your support, patience, prayers and love

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LIST OF ABBREVIATIONS

AACN : American Association of Critical-care Nurses

ASARECA : Association for Strengthening Agricultural Research in Eastern and Central Africa

Bio-Innovate : Bio-resources Innovations Network for Eastern Africa Development

CIAT : International Center for Tropical Agriculture

DAP : Di-Ammonium Phosphate

ECABREN : Eastern and Central Africa Bean Research Network

FAO : Food and Agriculture Organization

GAO : Government Accountability Office

GEAR : Graduate Environmental and Agricultural Research

ISABU : Institut des Sciences Agronomiques du Burundi

JKUAT : Jomo Kenyatta University of Agriculture and Technology

NSW : New South Wales

PABRA : Pan African Bean Research Alliance

PAI-ISABU : Projet d'Appui Institutionnel-ISABU

PI : Principal Investigator

REPOA : Research on Poverty Alleviation

RUFORUM : Regional Universities Forum for Capacity Building in Agriculture

SCARDA : Strengthening Capacity for Agricultural Research and Development in Africa

SDC : Student Development Centre

SHERPA : Securing a Hybrid Environment for Research Preservation and Access

SSC : Statistical Services Centre

ABSTRACT

In Burundi, agricultural sector faces several constraints among them climate variability, increasing population density, pests and diseases and soil degradation. These factors lead to very low (and declining) levels of agricultural productivity and food insecurity. Agricultural research institutions are the channel for enhancing crop production through agricultural research for development. From this perspective, a one year attachment has been undertaken for improving research methods on bean breeding at Burundi Agronomic Sciences Research Institute (ISABU). Activities such as reviewing and designing research instruments (protocols, questionnaires), data analysis, data management, statistical advices in experimental designs, and training on use of statistical software. These activities were accomplished while participating in the implementation of three ongoing projects in bean research component. These projects were (i) Improving bean production and food security through selection of bean varieties for the five agro-ecological zones of Burundi, (ii) Promoting the use of improved agronomic practices (agro-systems) based on climbing beans in the Great Lakes region, and (iii) Value added bean technologies for enhancing food security, nutrition, income and resilience to cope with climate change and variability challenges in Eastern Africa. This one year internship revealed that for quality research, scientists with different expertise are required to work together as a team from the planning stage up to findings publication. Moreover, research institutions should have facilities such as access to scientific publications, statistical services unit well provided for appropriate and updated software.

CHAPTER ONE

INTRODUCTION AND BACKGROUND INFORMATION

1. 1. Research Methods

Research is a systematic, diligent inquiry or examination of some field of knowledge undertaken to establish fact or principles through collecting and analyzing data. The goal of formal scientific research is to build theory that predicts a reaction, relationship, or other phenomena when found in different situations. This is achieved through research methods, the means by which a person (Researcher) gives order to answering questions and testing hypotheses (Guerin *et al.*, 2001).

Sommer and Sommer (2001, quoted in Guerin *et al*., 2001) distinguished five formal systematic research methods that are common among researchers. These methods include (i) Observation, (ii) Surveys, (iii) Experiment, (iv) Case study, (v) Visual and Content analysis. These strategies present opportunities and differences for different types of questions and ways of gathering of information.

Observation occurs when researcher is interested in determining what people do (their activities, behaviors) in public places or how an environment is actually being used.

This method is often used in conjunction with other methods, such as a follow-up to a survey or prior to a survey to locate critical areas that then serve as points of questioning (Guerin *et al.*, 2001).

Survey research is a systematic method for studying behavior that cannot be observed or experimented on directly. Surveys usually require larger numbers of respondent to give accurate meaning to the results. There are two instruments frequently used to collect survey data, the interview and the questionnaire. An interview is a conversation or discussion based on questions researchers want answered while a questionnaire is a series of written questions on a topic about which the subjects' opinions are sought (GEAR, 2009).

Experiments are used to test cause-effect hypotheses. The purpose is to determine the effect of the independent variable upon the dependent variable. All other influential variables must be either eliminated or their effect controlled. This requires using standardized procedures to hold all conditions constant except the independent (experimental) variable. This standardization ensures high internal validity in comparing the experimental group to the control group on the dependent variable. That is, when internal validity was high, differences between groups could be confidently attributed to the treatment, thus ruling out rival hypotheses attributing effects to extraneous factors (Ross and Morrison, 2004).

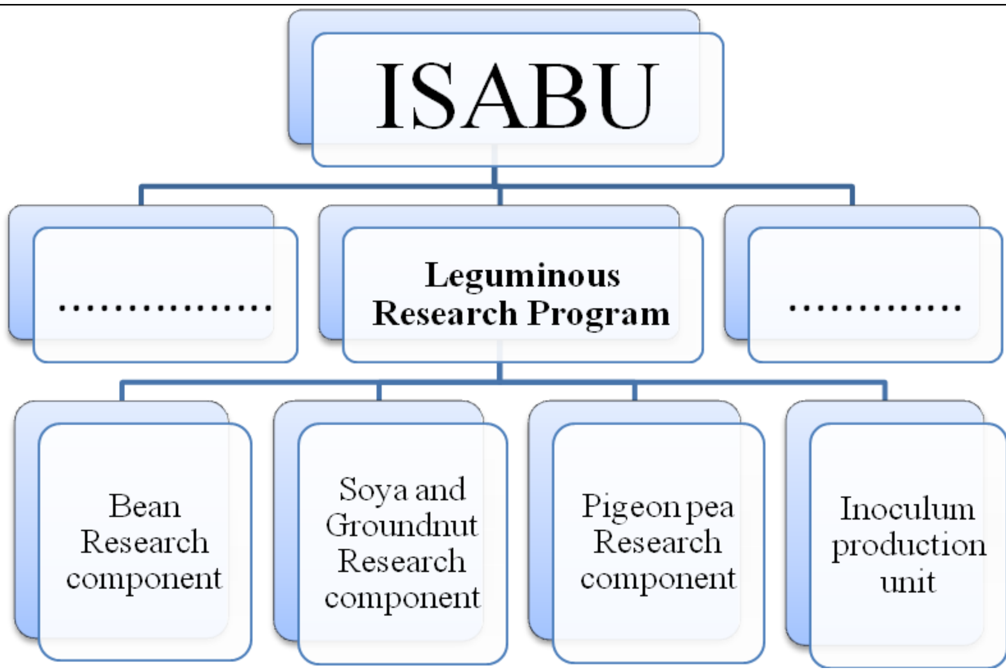
The case study is an in-depth investigation of a single instance involving an individual, group, or entire community. Case study method emphasizes the individuality and uniqueness of the participants. Interviews, surveys, and observations are strategies that might be used within a case study (Guerin *et al.*, 2001).

Visual and Content analysis systematically describes the form and content of written, visual, or spoken material. The intent of these methods and analyses are to find patterns that may be based in written or visual language (Guerin *et al.*, 2001).

1. 2. Burundi Agronomic Sciences Research Institute (ISABU)

The attachment was done at Burundi Agronomic Sciences Research Institute (Institut des Sciences Agronomiques du Burundi-ISABU). The institute is mandated to provide high yielding animal and plant seeds, adapted to the prevailing conditions in the different agro-ecological zones of Burundi. Likewise, ISABU establishes improved agronomic practices that support improved animal and plant seeds in contributing to food secure and income generation. This is done by carrying out research aimed at selecting and disseminating appropriate technologies for both agricultural and animal production.

At ISABU, research activities are carried out within research programs, the smallest unit of research being research component. Each component focuses research on a certain plant cultivated in Burundi. The chart below (Fig 1) highlights the way leguminous research program is organized.



Legend

ISABU : Burundi Agronomic sciences Research Institute

……… : Blank boxes with dots (………) stand for other research programs

Fig 1: Organization chart of Leguminous Research program at ISABU research Institute

1. 3. Projects supported

During this internship, active participation in implementing research activities planned in bean research component has been done. Three regional projects were ongoing and titled as follows:

a) Improving bean production and food security through selection of bean varieties for the five agro-ecological zones of Burundi

The project aimed at selecting bean varieties that are adapted to different agro ecological zones of Burundi. The expected results of the project were to develop and disseminate high yielding bean varieties that are adapted to different agro ecological zones of Burundi. This was done trough experimental trials such as preliminary trials, advanced yield trials, and confirmatory trials in different agro-ecological zones. These activities were carried out in research stations distributed across the country. At advanced and confirmatory trials levels, participatory selection involved farmers for releasing new improved bean varieties.

b) Promoting the use of improved agronomic practices (agro-systems) based on climbing beans in the Great Lakes region

The project aimed to improve the productivity of the bean production system and the nutritional status of households in the Great Lakes region. The project was focused on identifying improved technologies based on climbing bean varieties and strengthening their integration in bean production system.

The expected results were the more productive and profitable systems based on climbing beans identified and availed for release.

c) Value added bean technologies for enhancing food security, nutrition, income and resilience to cope with climate change and variability challenges in Eastern Africa

The objective of the project was to contribute to improved food and nutritional security and income through increased bean productivity, value addition and marketing, while conserving the environment in drought-prone areas of Burundi, Ethiopia, Kenya, Rwanda and Tanzania.

For the Burundi component, the expected outcomes from the project were the following: (i) Nucleus of seed of new high yielding drought tolerant, and market preferred bean varieties are available; (ii) One innovation platform established to enhance functional linkages among actors along the bean value chain.

The first project was funded by Pan Africa Bean Research Alliance (PABRA) through Eastern and Central Africa Bean Research Network (ECABREN), while the second and third projects were funded by Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) and Bio-Innovate projects, respectively.

1. 4. Problem statement and justification

ISABU is a research institute where activities are carried out within research components. In this institution, research activities are mainly done by scientists assisted by field data collectors (technicians) for daily monitoring and data collection. The major challenges for researchers are the lack of appropriate skills for conducting research activities well. Research instruments (protocols, data collection sheets) are not well designed, the lack of appropriate skills being the major reason in failing to design these research instruments. Furthermore, the findings are not widely published due to the lack of knowledge on scientific writing (ISABU, 2010). Note that RUFORUM (2009) has also identified limited capacity in research methods as a constraint to quality research for development in Sub-Sahara Africa. Therefore, there is a great need to enhance abilities of scientists in carrying out research activities effectively through capacity building and research consultancy sessions.

1. 5. Objectives of the attachment

The broad objective was to improve research methods in plant breeding at ISABU. Specifically, the attachment aimed (i) To offer statistical consultancy through participation in research team work while contributing to data management and data analysis; (ii) To build capacity among researchers and field research assistants on statistical analysis and the use of statistical software; (iii) To evaluate the status and contribute to the improvement of the quality of scientific reports and publications; and (iv) To evaluate the effect of three staking techniques on yield of climbing beans.

CHAPTER TWO

LITTERATURE REVIEW

2. 1. Research team work

Team work does not mean everyone getting together to work on the same task. It means establishing together the question that needs to be answered, each team member taking responsibility of doing the work for a particular task. Later, in a group meeting, results of each task are put together for establishing a common understanding (Mason, 2003).

The multi-dimensional and thus multi-disciplinary nature of many problems requires a team approach. This approach encourages staff members with complementary skills and competencies, to coordinate their efforts. By establishing priorities, concentrating financial resources, and combining knowledge and expertise, it is possible to have greater impact on serious problems through program efforts. Such efforts can serve to lighten work load, reduce duplication of efforts, and produce a result greater than all of separate efforts **(**Gibson *et al*., 1980).

In their composition, teams should reflect multidisciplinary skills to handle task diversity in an appropriate manner. These skills should match job responsibilities and tasks to be carried out (Becton *et al*., 2008).

According to Coulehan *et al.* (2006), most research teams are made up of at least five key members namely:

(i) The Principle Investigator (PI), who leads the project and ultimately responsible for a project and its research. The PI enables other team members to conduct research, and is the final authority on all scientific issues related to the project. A big project may have Co-Principal Investigators;

(ii) The Research Director, who controls the project. By directing the protocol for how the research and data collection are carried out, the Research Director often knows more about the day-to-day operations of the project than the PI. The Research Director works closely with the PI to both report on and redirect research;

(iii) The Research Associate (Project coordinator), who coordinates the project. This individual carries out the research itself, collecting data and assessing the effectiveness of project protocol, suggesting changes to the methodology as needed;

(iv) The Research Assistant, who performs the day-to-day tasks of a project, including collecting and processing the data and maintaining equipment; and

(v) The Statistician, who analyzes the project data. The statistician may simply analyze and report on the data after data collection has been completed or may be involved in the construction and analysis of research throughout the entire project.

Additional team members may be involved in research studies, including field/laboratory technicians, interns or student researchers, grant administrators, and others. Their roles should be defined by the PI at the outset of the project. Benefits from team work are reduced costs, improved quality of research and services provided, increased employment involvement, reduce absenteeism, enhanced creativity and innovation, create better ability and flexibility in the organization (Farrington, 2008).

2. 2. Statistical consultancy

Statistics is a science applicable almost everywhere; wherever there are data, there are statistics. Moolman (2010) defines statistical consulting as "the collaboration of a statistician with another professional for the purpose of devising solutions to research problems". Virtually all statisticians get requests to help with problems that involve statistical data analysis and/or application of statistical methods.

While the person requesting the help (the client) is familiar with the description of the research problem, the statistician needs to express the problem in a form which statistical methods can be applied to solve the problem. This is usually the starting point of the process of communication that takes place between the statistician and the client.

Boen and Zahn (1982) distinguishes two approaches of statistical consulting namely (i) Collaborative consulting where the statistician and the researcher(s) work together in a team (ii) Straight consulting where the statistician is called upon to fulfill a specialist consulting role in the research.

Prior to the first meeting with the statistician, the client is requested to bring along any information/data that had already been collected (computerized or in manual form) and explains the problem and the type of help needed. The statistician listens carefully to the explanation and guides the explanation towards the root of the problem by asking well directed questions in non-technical language. At this time the client supplies the following information: (i) precision about the objectives of the analysis, a brief background to the problem and how the results obtained from the study are to be used, and (ii) description of the variables and data that are being studied and possible relationships that might have to be investigated.

2. 3. Seminars and training courses

Training is defined as a technique of development of skills, knowledge and aptitude to perform a job. Training involves transfer of new knowledge, skills, behavior and aptitude to perform specific roles in the workplace (NSW, 2009). In other words, training means helping people to learn how to do something, telling people what they should or should not do, or simply giving them information.

The effectiveness of training requires also management plan. Major steps for effective planning and delivered of training are identification of the participants and setting a date for the training course, assessing training participants' needs, setting training objectives, preparing and organizing training content, selecting training methods and preparing materials, organizing the training course and developing an evaluation strategy (FAO, 2005).

McNamara (1980, quoted in McClelland 2002) qualifies training as essential not only to increase productivity but also to motivate and inspire workers by letting them know how important their jobs are and giving them all the information they need to perform those jobs. There are several ways of training people, the table below (Table 1) describes some advantages and draw backs of five different methods of training.

Table 1: Advantages and draw backs of five different training methods

Training method	Advantages	Draw backs
Trainer presentation (Lecture)	▪ Keeps group together on the same point ▪ Time control easier ▪ Useful for large group size	▪ Can be dull if used too long without learner participation ▪ Retention is limited
Structured Exercise/Role Play	▪ Aids retention ▪ Allows practice of new skills in a controlled environment ▪ Learners actively involved	▪ Requires preparation time ▪ May be difficult to tailor to all learners' situations ▪ Needs sufficient class time for exercise completion and feedback
Individual reading Assignments and individual exercise	▪ Saves time (learners read faster than trainer can talk). ▪ Material can be retrained for later use	▪ Boring if used too long without interruption ▪ Learners are different paces ▪ Difficult to gauge if people are learning
Facilitated Group discussion	▪ Keep learners interested/ involved ▪ Learner resources can be discovered and shared ▪ Learning can be observed	▪ Learning points can be confusing or lost ▪ A few learners may dominate the discussion ▪ Time control is more difficult
Demonstration	▪ Aids understanding and retention ▪ Stimulate learners' interest ▪ Can give learners a model to follow	▪ Must be accurate and relevant to learners ▪ Written examples can require lengthy preparation time

Adapted from Mihall and Belletti (1999)

2. 4. Scientific report

A report is a written document that presents information by using short, concise paragraphs, graphics wherever possible (tables, graphs, illustrations). It aims to inform, as clearly and succinctly as possible (Jifsan, 2010). A report is a presentation of facts and findings, usually as a basis for recommendations written for a specific readership, and probably intended to be kept as a record (Hipp and Velliaris, 2008). Some reports are short and informal and cover topics or a small project while the formal reports are often longer and provide detailed descriptions of a long or expensive project that has been completed (SDC, 2000).

Most companies and organizations have their own particular format for reports. Whilst not mandatory, sections for a typical scientific report include title, authors, abstract or summary, table of contents, introduction, experimental techniques and methods, results and discussion, conclusion and recommendations, references, and appendices (Barnes, 2000).

Reporting is a necessary and integral part of the research activity, useful and valuable. It permits other people to know about developments of a project, encourages them to do their own projects, and guides governments officers, donors, and decision makers for evaluation (Bartle, 2007).

2. 5. Research protocols

Research is a systematic process of collection, analysis and interpretation of data for generating new knowledge or answering certain questions. Research involves various people working together. These include the investigators, laboratory and field staff, the statisticians, the institution in which the research is carried out, those who provide the finances, the participants or study subjects and their community (Sanjay *et al*., 2005).

The protocol is the written description of everything that will be done in the experiment, starting with the objectives and going right through to the analysis, interpretation, and use of the data. Written for every experiment, the protocol must be shared before the experiment starts to get input from others. The protocol must be sufficiently detailed for someone else to take over the experiment pathway through, or to make sense of the data at the end of the experiment, even if the PI is no longer around. The protocol should be kept up-to-date, records exactly what is going on, and securely archived so that information about the activity can be found in the future (GEAR, 2009).

In research, majority of the studies to conduct are either observational or experimental. Therefore, it is essential to elaborate and follow a research protocol. This will increase the likelihood that the conclusions drawn from the research will be scientifically sound.

2. 6. Research proposal

Many disciplines require written proposals before an experiment can be run, before a presentation can be made, before a seminar paper can be written (Gibson, 2006).

In general, most agencies provide detailed instructions or guidelines concerning the preparation of proposals (and, in some cases, forms on which proposals are to be typed). Obviously, such guidelines should be studied carefully before writing the draft. However, all proposals must include certain basic information. These basics include why the project, what the project intends to do, where and how it will be done, and who will be doing it (Thackrey, 2010).

The purpose of writing proposal is to convince the funding agency of the merits of research project and secure the agency's financial backing. Most agencies maintain a panel of peer reviewers who decide which applications will be funded. They review each application and determine its scientific merit and the potential outcomes of the proposed research. A successful proposal shows a link between the mission of the funding agency and the proposed research. It should be specific and adheres to the instructions and guidelines provided by the funding agency including technical requirements such as page limits and deadlines for submission (AACN, 2003).

In most cases, proposals fail due to absence of innovative hypotheses, errors in logic and experimental design, as well as in presenting and expressing unrealistic ambitious or wholly unjustified budget (Karentz, 2006). This can be avoided by including inter-disciplinarity aspect while writing proposal. Indeed, an assessment of proposals for research grants submitted to Research on Poverty Alleviation (REPOA) found that although single authors accounted for the highest number of submissions, it is the multiple authors who had the highest acceptance rate (Kikula and Qooro, 2007).

There are two types of proposals, the letter proposal (concept note) which is a preliminary expression of interest to an investor while the full proposal is the development of letter proposal with donor's consent. Where no format has been specified by a funding source, a typical proposal outline consists of a title page, executive summary, introduction, problem statement, project goal, project purpose, project objectives, expected outputs, study methods/research approach, budget and budgetary notes, work plan, references, and appendices (Gudu, 2006).

Depending on the academic discipline, a research proposal may include other required features. For instance, the logical framework may be included in a project proposal for the project evaluation purpose (Gibson, 2006).

2. 7. Data management

The 'raw materials' of a field or laboratory research activity are data. These are the numbers resulting from measurement, together with information about where they came from. Data management refers to any activity concerned with looking after and processing this information (Muraya *et al*., 2002).

Data management can be defined as the process of designing data collection instruments, looking after data sheets, entering data into computer files, checking for accuracy, maintaining records of the processing steps, and archiving it for future access. It also includes data ownership and responsibility issues (Muir-Leresche *et al.*, 2004).
The importance of data collection includes enabling those involved in the research to more accurately and asses their work, to allow independent researchers to replicate the process and evaluate results, to provide justification to sponsors for expenditures and project decisions, and to yield reliable and valid results for testing hypothesis.

For larger projects, maintaining handwritten records is not possible, electronic records are preferable for such projects. Indeed, electronic data storage allows data to be appropriately used in the future and storage format that is easily adaptable to evolving computer hardware and software. There are some additional considerations that are unique to electronic data storage, including rapid access to the data, fast read, low cost, ability to archive the data, removability, a backup system. Electronic records allow researchers to efficiently access and compare information from different sources and across similar projects (Schleicher, 2005).

In data management, research team members have various responsibilities. The Principal Investigator and Research Director are usually responsible for most of the tasks related to data management. Research Associates and Research Assistants are primarily responsible for data collection, while statisticians are responsible for analysis (Coulehan *et al*., 2006). The main reasons for establishing data management standards are to ensure the quality of the data. The errors that can occur during data preparation are usually linked with the procedures adopted for instrument design, coding and data collection procedures, and data entry methods (Schleicher, 2005).

Data management is important due to the fact that it enhances data quality with metadata and provides efficient data processing. Data used for analysis and reaching conclusions must be correct. If proper attention is not paid to data management it is too easy to make a mistake in the processing, resulting in incorrect conclusions. Data has to be documented and described so that it makes sense, not just to the researcher who collected it, but in the future and to others. Field data is expensive to collect so must be considered as valuable, but its value is maintained only if it can be used in the future (Schleicher and Saito, 2005).

2. 8. Data sharing

Research institutions and funding agencies have their own requirements for when and how much of a research project should be shared. Sharing information while the project is still in progress should be done cautiously, since the implications of the data may not be fully known. However, in some cases preliminary data should be shared immediately with the public and/or other researchers since it would be of immediate benefit (for instance if a research project found that a new drug placed subjects at grave risk or greater benefit) (Steneck, 2004). In addition, many researchers find it worthwhile to present preliminary findings in a conference setting before the study is complete to inform peers about their forthcoming research.

After a project's research has been published or patented, any information related to the project should be considered open data. Other researchers may request raw data or miscellaneous information related to the project in order to verify the published data or to further their own research project. However, each project should evaluate its ability to share raw data in terms of specific needs and budget constraints.

By sharing research results, a project may advance new techniques and theories and benefit other research. It encourages collaboration between researchers in the same field or across disciplines. Additionally, reporting of clinical research data can have a direct impact on the quality of health care provided to patients.

Data sharing usually occurs once a study has been completed. Data reporting includes discussion of the data, the data analysis, and the authorship of a project, especially in the context of a particular scientific field. Data sharing and data reporting are typically accomplished by publishing results in a scientific journal or establishing a patent on a product (Levesque, 2010).

2. 9. Data analysis

Data analysis consists in summarizing large sets of raw data, express processed data as meaningful content with the intent of generalizing (or inferring) the results to the larger population from which the sample was drown (Guerin *et al.*, 2001). For many researchers, it would be time consuming and undesirable to use all of the data collected over the course of a study. If it is to be translated into meaningful information, data must be managed and analyzed in an appropriate fashion (Coulehan and Wells, 2006).

Analysis of data is a process of inspecting, cleaning, transforming, and modeling data with the goal of highlighting useful information, suggesting conclusions, and supporting decision making (Kageler *et al.*, 2001).

In data analysis is a process, within which the following phases can be distinguished (i) initial data analysis (assessment of data quality), (ii) main data analysis (answer the original research question), and (iii) final data analysis (necessary additional analyses and report).

Data analysis is often delegated to a biostatistical services department (in the case of a large institutional research) or to a project's statistician. If an outside statistical service is hired to do the analysis, the PI should work with the agency to ensure that the agency understands and complies with that project's data management protocol. While some members of the research team will be minimally involved with data analysis, they should all understand the data analysis plan and be able to interpret the results within the context of the study. There are several statistical packages involved in data analysis.

The following table highlights features, limitations and availability of the most statistical packages used for both experimental and survey data analysis.

Table 2: Features and limitations of most used statistical software

Software	Desirable features	Limitations	Pricing and availability
Excel	▪ Excellent in data management ▪ Good in graphics and tables	▪ No recommended for statistical analysis	▪ Software available on most computers
Gen Stat	▪ User friendly, menu based ▪ Excellent for experiments ▪ Suitable for agricultural studies	▪ Not particularly good for surveys	▪ Reasonable price ▪ Gen Stat Discovery is a free version
SPSS	▪ Standard for survey data ▪ Very popular	▪ Poor at ANOVA	▪ Very expensive
R	▪ Excellent in graphics ▪ Object oriented language ▪ Suitable for statistical theory development	▪ Need to know the C-language ▪ Not menu driven	▪ Free download
Epi Info	▪ Designed for surveys ▪ Good for survey data entry	▪ Limited statistical facilities ▪ Primarily for health applications	▪ Free download
CS Pro	▪ Designed for census and survey data ▪ Good in tabulation	▪ Limited statistical facilities	▪ Free download
SAS	▪ Can do everything e.g. surveys, data management, experiments	▪ Need to know the C-language ▪ Not user friendly	▪ Very expensive to maintain license

Adapted from Kageler *et al.* (2001)

CHAPTER THREE

IMPROVING QUALITY OF SCIENTIFIC PROTOCOLS, REPORTS AND PUBLICATIONS

ABSTRACT

A complete plan of scientific activity implementation should be written in a research protocol. Indeed, a research protocol is the detailed document that lays out all stages of the research activity. Well implemented through data collection, the research protocol is a great instrument for achieving valuable findings. In most cases, scientists fail to publish their findings due to the current system of scientific publishing besides of some scientists who lack appropriate skills for scientific publication writing and designing of data collection tools. The present activity aimed to review existing research protocols and publications at ISABU and suggest improvements if needed. Both research protocols and scientific publications were reviewed. Prior the review, a template to which the content of the existing document (report or protocol) was compared had been made. While reviewing research protocols, annual, semi-annually, and quarterly reports, slight weaknesses in their contents have been identified. To address this, fifteen senior scientists attended a seminar on scientific paper writing and a short presentation on experimental protocol writing. They received also guidelines for writing both scientific report and research protocol.

3. 1. Introduction

After proper and complete study planning, the plan should be written down in a research protocol. Indeed, the protocol is the detailed plan of the study and can act as a manual for members of the research team to ensure they adhere to the methods outlined. It is a necessary guide if a team (not a single investigator) is working on the same research activity (Ross and Morrison, 2004).

Before publishing findings, research activity is considered incomplete. There are of course, reasons for publishing research findings other than the career and reputational motivations of authors. Research is an ever–evolving discipline, without access to the latest research findings, researchers would find themselves lagging behind or repeating work that had already been carried out elsewhere (SHERPA, 2004).

Hubbard Bill (2004) identified the way publishers operate currently to be one of the problems that limit scientists to publish their findings. In their capacity as authors, researchers give their articles to journals in order to achieve 'impact' not income. But publishers of journals want to generate income from research papers and so charge subscription fees for journals whilst restricting their circulation (to subscribers only). Publishers also often require authors to sign over copyright completely, preventing authors from disseminating their work in other ways. This practice takes ownership of the work away from the researcher and the institution.

Even if peer review journals have writer teams for reviewing and editing paper prior publication, writing skills constitute a barrier for some scientists in disseminating research outcomes. Indeed, one may fail to publish his findings due to the weaknesses observed in data collection forms. On the other hand, scientists cannot embark on paper writing due to the lack of appropriate skills in scientific paper writing. This chapter was set up to review the existing data collection forms (protocols) and publications written by scientists of ISABU research institute and suggest improvements if needed.

Detailed review of protocols and annual reports has been done and pointed out slight weaknesses in their constitution. Indeed, for protocols and scientific reports, sections such as Introduction, Background information, Discussion, References did not convey sufficient information. Indeed, these sections should concisely review the literature that is relevant to the problem investigated (O'Brien and Wright, 2002). Consequently, guidelines on writing research protocol for experimental studies and scientific reports were provided on top of a seminar on scientific paper writing.

3. 2. Methodology

A detailed review of the existing experimental protocols and scientific publications mainly annual, semi-annually, and quarterly reports was done and came up with a template for both research protocol and scientific report. This review consisted of reading existing protocols and publications in order to suggest improvements afterwards.

Through literature review, guidance on writing both scientific report and research protocol have been made and used as templates to assess the quality of the published scientific reports and the current research protocols. This assessment was done, using the content analysis method, by comparing the content of the existing document with the template produced. A one day seminar on scientific paper writing techniques was organized for senior scientists in addition to a short presentation on writing research protocol for experimental studies. Training materials, hand outs and appropriate exercises were also prepared. Trainer presentation (Lectures) and demonstration training techniques were used for effectiveness in training. At the end of the training session, participants evaluated the seminar in its aspects of training content, training presenter, the training materials, and overall comments and suggestions. A training evaluation sheet was prepared for this purpose (Appendix 3).

3.3. Results

The review of existing protocols and scientific reports identified weaknesses in these documents. Compared to their templates, the content of reviewed documents is summarized in table 3. Guidelines on writing research protocols for experimental studies and scientific reports are presented in appendix 1 and appendix 2. Two short presentations one on randomization of a Randomized Complete Block Design and the second on writing research protocol for experimental studies were offered.

In addition, fifteen senior scientists attended a seminar on scientific paper writing. Data collected during seminar evaluation were submitted to Census and Survey Processing System (CSPro) for analysis and summarizing participants' evaluation of the seminar. Figure 2 highlights participants' evaluation of the seminar session offered. The seminar was evaluated as excellent, very good, good, weak, and poor by 40, 49, 7, 2, and 1% of participants, respectively.

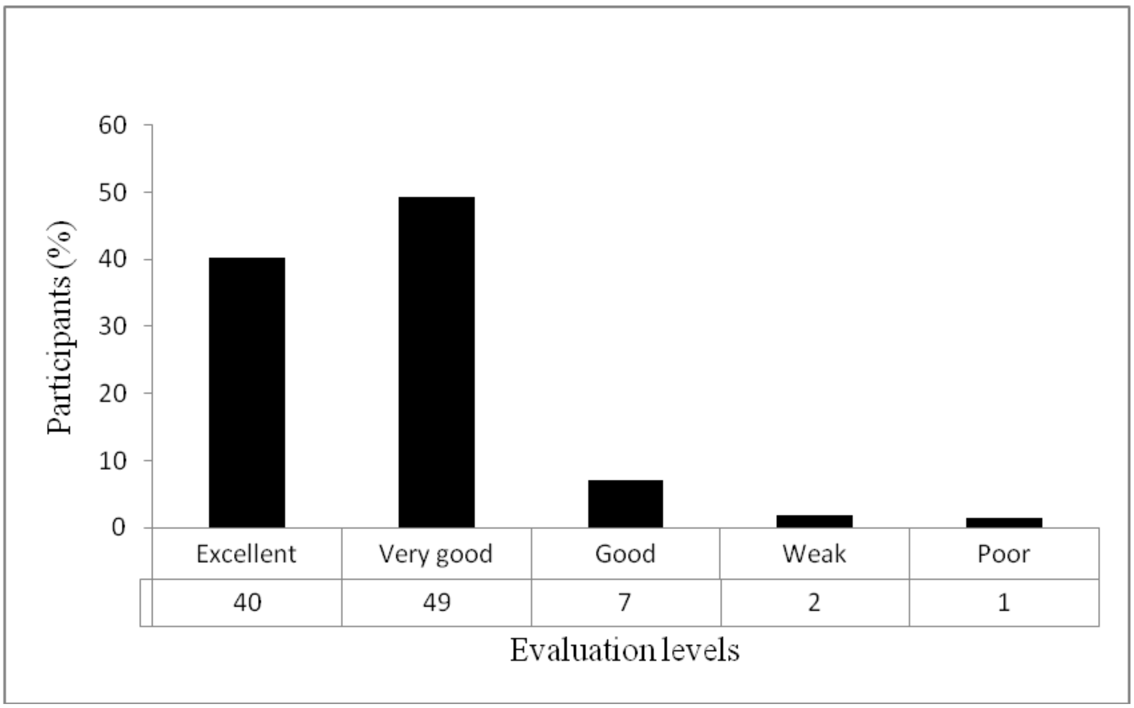


Fig 2: Participants' evaluation of the seminar on scientific paper writing

Table 3: Summary of the content of protocols and scientific reports reviewed

Scientific report			Research protocol		
	Template of scientific report	Content (sections) of reviewed reports		Template of research protocol	Content (sections) of reviewed protocols
1	Title page	Present	1	Title page	Present
2	Summary	Absent	2	Protocol summary	Present
3	Table of contents	Present	3	Problem statement	Absent
4	Introduction	Present	4	Objectives	Present
5	Methodology	Present	5	Methodology	Present
6	Results	Present	6	Expected outcome	Absent
7	Discussion	Absent	7	Budget summary	Absent
8	Conclusion and Recommendations	Present	8	References	Absent
9	References	Absent	9	Annex	Present
10	Acknowledgment	Present	9.1	Data collection sheet	Present
11	Appendices	Absent	9. 2	Budget details	Absent

3. 4. Discussion

After reviewing existing publications of which ISABU scientists are the authors, some gaps were identified. First of all, scientific publications were largely formed by annual, semi-annually, and quarterly reports. Research protocols reviewed pointed out slight weaknesses especially in the content of sections such as problem statement, methodology, budget summary, expected outcomes, references, and annex sections. For scientific reports, major weaknesses were found in the introduction, discussion, references, and appendices sections.

The major constraint accounted for this being the limited access to the journal literature. In fact, there are problems for researchers in their capacity as readers of the journal literature. Most of the refereed literature is not easily available to most researchers. Such inefficiencies in the scientific communication process can hold back scientific progress itself (Bill, 2004).

SHERPA (2004) suggests that all researchers, regardless of the nature of their institution, should be granted access to the scientific journals they need to carry out their work effectively.

Fortunately, there is now an international movement aiming to address the problems associated with the current scientific publishing system. A key objective of this movement is that content should be made freely available wherever possible on the World Wide Web. Providing free and unrestricted access to scientific papers has the potential to make scientific publishing more effective and efficient (Koltay, 2008).

The movement for open access has focused on two strategies: open-access journals and open-access repositories. The two strategies are complementary and achieve the key aim of improving access to the scientific literature. Both offer the potential for major efficiencies in elaborating research instruments and producing scientific publications with quality.

CHAPTER FOUR

PARTICIPATION IN RESEARCH TEAM WORK, DATA MANAGEMENT AND DATA ANALYSIS

ABSTRACT

Research activity is a complex task that requires people with different expertise to work together as a team. Indeed, putting into play abilities of all team members always leads to success. Protocols and questionnaires were designed into groups before implementing any research activity. Field data collectors were trained on data entry in excel, data entry screen designed in CSPro facilitated enumerators in computerizing survey data. Data sheets were documented with metadata for ease of data archiving and future use. Data collected from the field were processed and submitted afterwards for statistical analysis. Since most of datasets analyzed were collected from experimental studies, Gen Stat 12th Edition was largely used for fitting either analysis of variance (ANOVA), simple linear regression or generalized linear regression models (Logistic and Poisson regression models). Moreover, ten junior scientists attended two day training on the use of Gen Stat 12th Edition for fitting ANOVA and Simple linear regression models. Participants appreciated these training sessions as activities with great value for data management and data analysis. For instance, train field data collector in data entry is very important in minimizing data entry errors.

4. 1. Introduction

Generally research activities are aimed at advancing research by publishing new findings drawn from data collected from the field. According to Roberts (1995), it is usually an error of design or implementation that messes things up, not how data is handled. Most of bad researches are typically bad because investigators failed to sample appropriately, or assign subjects to groups appropriately, or failed to control the implementation of the treatments, or failed to use good criterion measures or finally, made claims in the discussion section that simply cannot be supported by the data that were collected. This should be alleviated by developing the spirit of working as a team in an organized manner to achieve a common goal. Indeed, each team member has his own personality and brings to the task particular skills, knowledge, and experience, which are different from those of other team members (Cardona and Wilkinson, 2006). In addition, working in team leads on performance effectiveness in terms of quantity and quality of outputs. Examples of performance effectiveness measures include efficiency, productivity, response times, quality, customer satisfaction, and innovation (Cohen and Bailey, 1997).

Data that are properly managed will be more accessible to other researchers, more likely to be re-visited and re-used in ways that may be different from their original intention, available to assist in the development, and more likely to be preserved (Debbie, 2007).

On the other side, data analysis consists of transforming the raw data into meaningful and significant conclusions that other researchers and the public can understand and use. Missing out any stage in data analysis can lead to unexpected results and fail to achieve study objectives (Coulehan and Wells, 2006). Data analysis should begin while formulating the study questions, and should continue until evaluators have made the last revisions in the report. Throughout this time, there are many opportunities to enhance the data analysis procedure and making later appropriate conclusions (GAO, 1992).

This chapter was suggested to (i) develop effective team work at ISABU while contributing to data management and data analysis through statistical consultancy discussions, and (ii) build capacity of scientists and field data collectors in both data management and data analysis.

Therefore, activities related to both research instruments (tools) designing and data management were organized in team work. Research protocols, questionnaires, proposals were designed within teams work besides statistical advises on experimental design, data management and data analysis. Two training sessions on data entry and data analysis offered. Indeed, junior scientists and field data collectors were trained, respectively on data analysis in GenStat, and data entry in Excel 2007. Datasets were processed before analysis and documented with metadata for ease of archiving and retrieval for future use. Statistical models such as ANOVA, logistic and Poisson regression models were fitted depending on the data distribution. For the survey study, data entry screen was designed prior data collection and data were processed in CSPro.

The approach of working in a team was positively appreciated especially for its efficiency and response times. Statistical advices have been appreciated for enabling clients in analyzing, on their own, their datasets and setting up well their field experiments.

4. 2. Methodology

Through team discussions, research instrument tools such as protocols, questionnaires, proposals were designed with scientists from different research programs. Researchers were provided appropriate advices in experimental design, data management and data analysis processes. Data management procedures were carried out while implementing the following projects: (i) Improving bean production and food security through selection of bean varieties for lowlands and highlands of Burundi, (ii) Promoting the use of improved agronomic practices (agro-systems) based on climbing beans in the Great Lakes region, and (iii) Value Added Bean Technologies for enhancing Food Security, Nutrition, Income and Resilience to cope with Climate Change and Variability Challenges in Eastern Africa.

Before setting up variety trials either on-farm or on- station, protocols were designed for data collection. Fields visits were organized for assessing the appropriate use of designed instruments while collecting data. Both questionnaire and data entry screen were prepared before implementation of baseline survey.

Data collected within the three projects, the same as data brought in by clients, were submitted to Gen Stat 12th Edition, SPSS 11.0, R 2.11.1, Instat+3.36, or CSPro 4.0 for analysis. Mainly, one and two way analysis of variance was fitted for assessing treatments effects. In case of significant effects of treatment factors, means were separated using Student-Newman and Keuls test at a significant level of $\alpha = 0.05$.

Two short training sessions were offered to address gaps identified in data management system and data analysis. Junior scientists, and field research assistants, chosen from different research programs, were trained in data analysis and data entry, respectively. Training materials, hand outs and appropriate exercises were also prepared. Trainer presentation (Lectures) and structured exercise training techniques were used for effectiveness in training. At the end of the training session, trainees evaluated the event in its aspects of training content, training presenter, the training materials, and overall comments and suggestions. A training evaluation sheet was prepared for this purpose (Appendix 3).

4. 3. Results

Proposals, protocols, questionnaires, have been designed with scientists from different research programs. Data management and experimental design constituted the core topics in statistical consultancy discussions. Questionnaire, data entry screen have been made for data collection prior the survey implementation.

In addition, twenty-three research assistants, selected from five different research programs, were trained on use of Excel 2007 for experimental data entry. The training session rated as excellent, very good, good, weak, and poor by 49, 34, 9, 4, and 3 percent of participants, respectively (Fig 3).

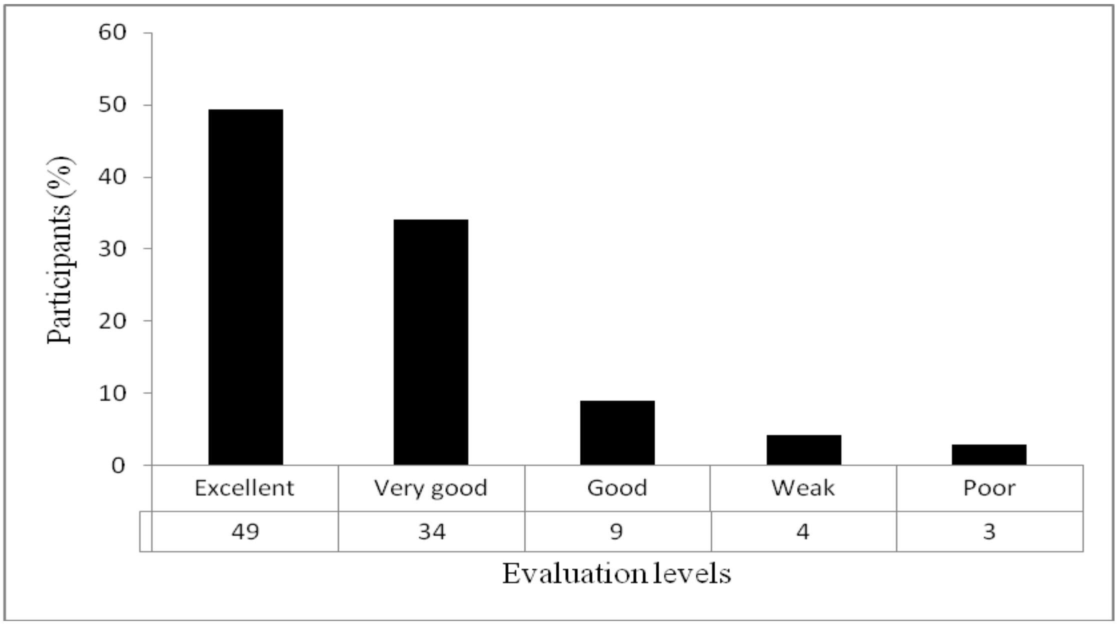


Fig 3: Trainees' evaluation of the training on use of Excel for data entry

Before analysis, the data collected from field experiments were processed with principal investigators of the projects. The ANOVA model was fitted for data that are normally distributed while Logistic and Poisson regression models were appropriately applied for data that follow binary and Poisson distribution, respectively. In case of unbalanced designs, regression models were applied for assessing the effect of independent variables upon response variables. Spreadsheets have been processed by adding to them information (metadata) for ease data analysis and data archive (Appendix 4).

Ten junior scientists (newly recruited i.e. with less than 5 years of experience) were trained on the use of Gen Stat for fitting both an analysis of variance and a simple linear regression models. They received at the same moment training on the use of statistical software (Gen Stat 12th Edition) and on data analysis (fitting ANOVA and simple linear regression models). Data collected during training evaluation were submitted to Census and Survey Processing System (CSPro 4.0) for analysis and summarizing trainees' evaluation of the training session. The training session was rated as excellent, very good, good, weak, and poor by 51, 37, 8, 1, and 3 percent of participants, respectively (Fig 4).

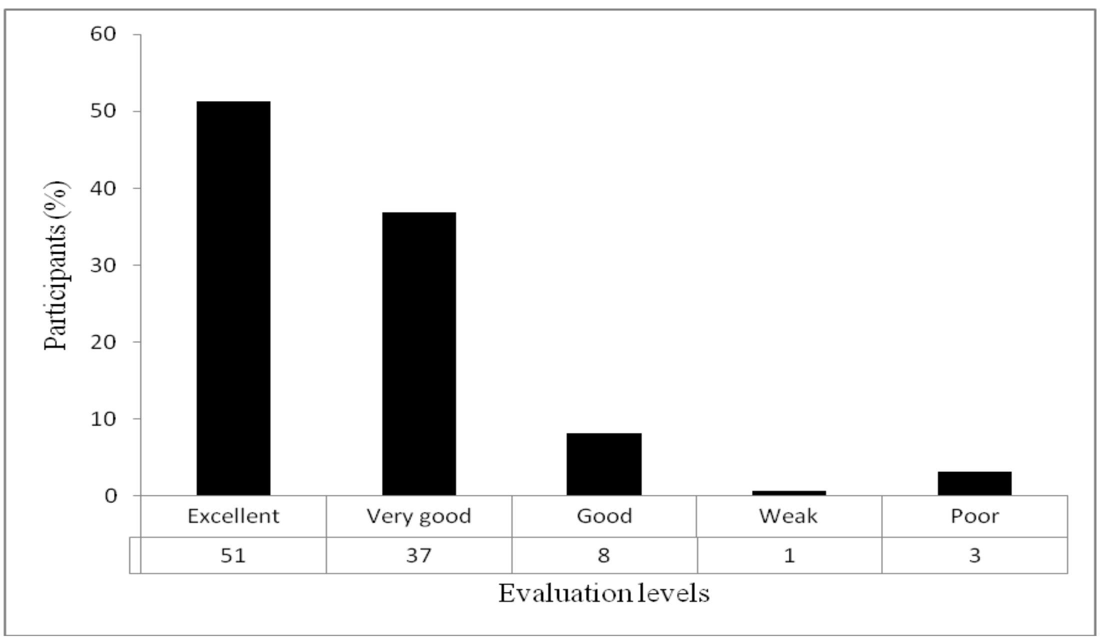


Fig 4: Trainees' evaluation of the training on use of Gen Stat for data analysis

4. 4. Discussion

As presented above, proposals, questionnaires, and protocols were designed in teams of scientists from different research programs. As confirmed by Cohen and Bailey (1997) project teams draw their members from different disciplines and functional units, so that specialized expertise can be applied to the project at hand. Their ability to do multiple activities simultaneously, rather than sequentially saves time, leads to cohesiveness and team's performance. Working in a team empowers people, and helps them develop autonomy, reduces stress, and contributes to job satisfaction (Cardona and Wikinson, 2006).

There are many thousands of experimental designs. Each design can be analyzed by using a specific analysis of variance (ANOVA) that is designed for that experimental design. One of the jobs of a statistician is to recognize the various experimental designs and help clients create a design and analyze the experiments by using appropriate methods and software (Wilson and Abeyasekera, 2006). In respect to this, experimental design, data cleaning and coding constituted core activities accomplished as statistical consultancy. Indeed, scientists came to seek advises before setting up their field experiments while data brought in for analysis required most time for cleaning and coding.

GEAR (2007) considers data management as the process of designing data collection instruments, looking after data sheets, entering data into computer files, checking for accuracy, maintaining records of the processing steps, and archiving it for future access. Abilities of both scientists and data collectors have been strengthened through capacity building in both data entry and data analysis. Datasets have been processed and documented with metadata information for ease in data archive, data retrievable, and future use.

For experimental studies, data are the values recorded in the field books, or record books that are to be entered into the computer and then analyzed. Data are often presented in simple data set with incomplete information for analysis. Additional information in the spreadsheet which gives details of, for example, the treatments, the type of design, the field plan and the units used for measurements, is also needed, for both the analysis and the archive. Such information is sometimes called “metadata”, and should be considered as equally as important as the data in the table (SSC, 1998).

Minimizing the time between data collection and data entry ensures data quality. Therefore data should be entered promptly, as soon as possible after data collection. This speeds the whole process and also helps the checking because some checks can indicate unusually large changes from the previous value, and odd values can then be verified immediately (SSC, 2009).

For some organizations, data analysis is taken as an exclusive activity of a biometrician. However, some of the research team members, if not all, should understand the data analysis procedure so that they can explain well their findings. Therefore, junior scientists were trained on how to fit the most suited models for experimental field research such as ANOVA and simple linear regression models. Indeed, regardless of the research skills of the statistician, there will always be the need for the researcher to have the best handle on how a study is designed, executed, and how data are analyzed (Roberts, 2005).

The choice of training on the use of Gen Stat is based on the fact that Gen Stat is the appropriate statistical package for agricultural field experiments which are most conducted at ISABU research institute. In addition, Gen Stat has a free version that is available to any scientist to use and has comprehensive menu to guide non-technical users to use statistics correctly and effectively (Buysse, 2004).

CHAPTER FIVE

EFFECT OF THREE STAKING TECHNIQUES ON YIELD OF CLIMBING BEANS IN HIGHLANDS OF BURUNDI

ABSTRACT

Three released improved bean varieties of common bean (*Phaseolus vulgaris* L.) representing climbing growth habit were tested under staking techniques with three different materials of staking. The experiments were conducted during the 2010B and 2011A cropping seasons in ten sites of Ngozi, Mwaro, and Karusi provinces of Burundi. The experiments were set up to compare genotypes' performance under the three different staking techniques and identify the staking technique that optimizes climbing bean production. A split plot design with six replications was used with bean genotypes and staking techniques as main and sub-plot factors, respectively. The bean genotypes varied significantly ($p<0.001$) in productivity under the three staking techniques. In addition, there was also highly significant ($p <0.001$) differences between the three staking techniques. However, there was no significant ($p = 0.595$) effect of genotype by staking techniques interaction indicating that genotypes selected for performance under staking with wood could also perform well in association with hybrid maize as well.

5. 1. Introduction

In Burundi, the majority of the population lives in rural areas and is employed in agriculture which is the primary sector of its economy. The high population growth in this country involves the reduction of arable land and therefore the crop production. The average population density is around 300 people per km^2. Due to the high population density the average of arable land is 0.5 ha per household (Republic of Burundi, 2007).

Beans are the most important food grain legume in Burundi. Because of their importance both to small holder producers and in the diet of the poor, more eco efficient production of beans is necessary (CIAT, 2009). Through Burundi Agronomic Sciences Research Institute (ISABU), the number of released bean cultivars has been increasing in Burundi. However, their performance under intercropping system has not been tested rigorously (Ntukamazina, 2008).

The overall objective of this study was to determine the best staking techniques for optimizing improved climbing bean yield. Specifically, the aims of this research were to (1) examine the relative performance of three climbing bean genotypes under three different techniques of staking, (2) observe if there is genotype by staking techniques interaction, (3) investigate differences within and between the three genotypes under the three staking techniques, and (4) identify the most suitable staking techniques for the climbing bean.

A split plot design with six replications (six farmers) in each of the three provinces was used in this experiment. The genotype and staking technique treatment factors were set as main plot and sub-plot, respectively. The experiment was an on-farm experiment conducted in 2010B and 2011A crop seasons.

5. 2. Methodology

The field trials were conducted on-farm during the crop season 2010B and 2011A with farmers from three provinces of highlands of Burundi namely Karusi, Ngozi, and Mwaro. Two treatment factors namely improved climbing bean variety, recommended for highlands areas, with three levels (AND 10, G2256, and VCB 81013), and staking techniques with three levels (Staking with wood, staking with string, and staking with growing maize associated with bean) were tested in split plot design in six replications (each farmer constituted a replication) . The main plots were occupied by variety treatment and sub-plots by staking techniques factor such that each bean variety was evaluated under the three techniques of staking on an experimental plot of 30 m^2. On top of other agronomic practices, a pre-planting dose of DAP at a rate of 100 kg ha^{-1} was fertilized with organic manure (10 t ha^{-1}) on bean sole plots. Intercropped climbing bean plots received 20 t ha^{-1} of organic manure in addition to 100 kg ha^{-1} of DAP. All these fertilizers were applied as a single dose (as one time) just before planting.

Data collected on grain bean yield were submitted to an analysis of variance to assess the effect of each staking technique on the three climbing bean varieties. This statistical analysis was fitted using Gen Stat 12th Edition.

The mean separation, in cases where there were significant differences among treatments, was done using Student-Newman and Keuls test to facilitate the comparison of all pairs of treatment means (Gomez and Gomez, 1983). Indeed, when analysis of variance is conducted and leads to rejection of the null hypothesis all we know is that at least one group mean differs from the rest. This leads to select the type of multiple comparison test, among them Student-Newman-Keuls test, to be performed in assessing, which means really differ from each other (Raftery *et al.,* 2002).

5.3. Results

For the treatment factor "Staking techniques", the grain yield collected show that the staking with wood technique is the most yielding technique among the three. The average grain yields obtained were 1849 kg ha^{-1}, 1490 kg ha^{-1}, and 531 kg ha^{-1} for staking with wood, with strings and with associated growing maize, respectively. The analysis of variance performed showed highly significant difference between the three techniques of staking climbing beans ($p < 0.001$) (Table 4). Furthermore, the multiple comparisons of means using the Student-Newman-Keuls test classified the three techniques of staking in three different groups of homogeneous means. These groups are group A formed by staking with wood technique, group B formed by staking with string technique, and group C formed by growing maize associated with climbing bean technique (Table 5).

For the treatment factor “Varieties”, the variety G13607 yielded more than the two others. Indeed, G13607 yielded 1468 kg ha^{-1} followed by AND 10 with 1387 kg ha^{-1} and VCB81013 with and 1014 kg ha^{-1}. The analysis of variance fitted showed highly significant difference among the three climbing bean varieties for grain yield (p-value <0. 001) (Table 4). Multiple comparisons of means using the Student-Newman-Keuls test classified the three climbing bean varieties in two groups of homogeneous means. Variety G13607 yielded as the same as variety AND 10 and better than variety VCB 81013 (Table 5).

However, the interaction genotype by staking techniques had no significant effect for the grain yield (p-value = 0.595).

Table 4: Results of analysis of variance of grain yield for staking and genotype factors

Source of variation	Degrees of freedom	Sum of squares	Mean square	F-value	Prob.
Block	5	5080994	1016199	9.39	
Variety	2	3511422	1755711	16.23	<.001
Residual 1	10	1082060	108206	0.46	
Staking technique	2	27853272	13926636	59.8	<.001
Variety*Staking	4	656021	164005	0.7	0.595
Residual 2	30	6986291	232876	0.54	
All interactions	36	15483696	430103		
Total	89	60653756			

Table 5: Multiple comparison of mean grain yield for staking and genotype factors

Treatment factor and factor levels		Mean grain yield (kg ha^{-1})	Group of means
Staking techniques	Staking with wood	1849	A
	Staking with strings	1490	B
	Staking with maize	531	C
Bean varieties	G 13607	1468	A
	AND 10	1387	A
	VCB 81013	1014	B

5. 4. Discussion

Results from this study show that climbing bean grain yields depend on the staking techniques. Staking with wood is the most optimizing climbing bean yield, followed by staking with strings. These two techniques of staking climbing beans could be alternative solutions to decreasing bean yield for smallholders. In Burundi and in Eastern Africa in general, because of population pressure, fragmentation of land parcels and concomitant decline in land sizes, there are limited opportunities for crop rotation. This leads to reduced soil fertility and a high incidence of diseases. Management strategies, including adoption of improved agronomic practices, to control soil fertility, disease, and pests are alternatives solutions to cope with gradually declining yields of bean (Buruchara *et al*., 2005).

From this study, it is evident that the climbing bean cultivars produced significantly higher yields under staking with wood (1849 kg ha^{-1}) compared to the other staking techniques. The adoption of this technology by smallholder farmers is mainly limited by the access to wood for staking. Therefore there is a need of adoption of the staking technique with strings whose average yield was 1490 kg ha^{-1}.

Climbing bean production could be improved by adoption of improved agronomic practices. Although some of these techniques and cropping systems have been adopted by farmers, it is necessary to identify those which are more productive and profitable. The use of different staking materials has advantages such as to protection of young forest trees and contributes greatly to the conservation of the environment (Wortmann *et al*., 2004).

CHAPTER SIX

GENERAL DISCUSSION, CONCLUSION AND RECOMMANDATIONS

6. 1. General discussion

6. 1. 1. Improving quality of scientific protocols, reports and publications

In some organizations research is carried out but the findings are not spread to the users, others scientists. For instance, at ISABU research institute research activities are carried out and findings only disseminated as intern reports. The existing research protocols and scientific reports reviewed revealed slight weaknesses especially in the content of problem statement, introduction, discussion, and references sections. The lack of appropriate writing skills and limit access to one's publications were identified to be the major constraints.

While investigating common weaknesses in scientific writing, Kikula and Qorro (2007) found that the most outstanding weak aspects in scientific writing include unsatisfactory sampling procedure, stating of hypotheses that could not be tested, using inappropriate methodology and inadequate literature review. To address this, the authors suggested strengthening research methods courses from basic degree level and train potential writers on scientific writing. In addition, potential writers should have successful access to published scientific papers and guidelines in the form of a scientific writing manual.

6. 1. 2. Participation in research team work, data management and data analysis

Research is a systematic process of collection, analysis and interpretation of data for generating new knowledge or answering certain questions. It is a complex activity that requires various people working together as team. This brings experts from several fields together and their shared knowledge, vocabulary, and skills develop potential changes in the scope of projects that are awarded (Cardona and Wilkinson, 2006). In this context, active participation in accomplishing activities such as proposal writing, protocol writing, questionnaire design, workshops, and survey implementation were accomplished within different teams.

As mentioned by Ellen and Marcus (2003), team work is becoming increasingly important both in profit-oriented and non-profit focused organizations. Thus, organizations with established team work operate with higher quality, speed and more economically (efficiently). In addition, studies have found that the key to successful completion of projects is often through the development of teams. Whereas in the past teamwork was used only for special projects, now it is often the norm (Castro, 1994).

Additionally, scientists received statistical advices on experimental design and data management. Indeed, according to Australian Statistical Conference (2008), there are four main stages in a research project when scientists might think of obtaining statistical consultancy.

The first is at planning the project, this ensures the more immediate advantage that the statistician may be able to suggest improvements in the design, in formulating the research question or research objectives, and carry out a sample size calculation. The second stage is when data has been collected before analysis, advice on data entry and data analysis cannot be overlooked. In the third scenario is when embark on the analysis but get stuck. The fourth possibility is when the paper was rejected despite the total confidence one had in design and analysis. The statistician may advise to start the analysis from scratch in order to get the paper published.

In most cases, the accomplishments of the project are dependent more upon its management than any other factor (Schoenbach, 2000). In fact, data management system is the set of procedures through which information is processed. It involves the collection, manipulation, storage, and retrieval of information. While the most visible tool is the computer, other “tools” are the instruments and data collection forms, quality control mechanisms, documentation, storage facilities for both paper and electronic media, and mechanisms of retrieval (Schoenbach, 2000).

During this attachment period, a particular attention has been made for some of these components of data management system. These include research instrument tools designing such as protocol and questionnaire, training on data entry, documented spreadsheets and data entry screen for storage.

The importance of designing data entry screen is the fact that the easier the data entry process is made the less chance there is of incorrect data being entered (SSC, 1998). For ease in data archiving, datasets have been documented by metadata. Indeed, when metadata are provided, a user can gain an understanding of the quality of a dataset and ascertain the suitability of that dataset prior to using it. Good metadata allows for improved data exchange, searching and retrieval (Chapman, 2005). Data analysis in general is the act of transforming and interpreting data with the aim of extracting useful information and drawing correct conclusions. Depending on the type of data, data analysis might include data processing, selecting or discarding certain data subsets based on specific pre-set criteria, transformation of values to relative quantities, normalization, rescaling, and a final statistical test of the derived data (Pfaffl *et al*., 2003).

From this study, since the research activities accomplished by scientists were field variety trials, analysis of variance was mainly fitted to test the differences between 3 or more treatment means. In case of significance treatment effect, follow-up comparisons of means were performed. However few datasets that conveyed data that is binary or Poisson distributed was fitted with logistic and Poisson regression models, respectively. Thus, processed data has been analyzed by fitting ANOVA, Simple linear regression or Generalized linear models (logistic and Poisson regression models). The ability of scientists in fitting simple linear regression and ANOVA models has been strengthened trough training sessions.

Statistical analysis is applied to summarize data in a shorter form that can allow making possible prediction based on the model fitted, i.e. making a conceptual or mathematical representation, from which we infer the process. Also, statistical analysis constitutes a way to quantify the confidence one can have while making inferences (Rossiter, 2006).

6. 1. 3. Effect of three staking techniques on yield of climbing beans in highlands of Burundi

Climbing Bean grain yield was significantly affected by staking technique and genotype treatment factors. The better performance of the staking with both woods and strings could be attributed to better light distribution throughout their canopy as a result of their upright growth. Such distribution increased light utilization. As reported by Finissa (1997) and Gebeyehu *et al*. (2006), yield of the shorter legume component like bean could be reduced from shading by the tall cereal component like maize, depending on the density of the cereal, among other things. According to Cardiner and Craker (1981, quoted in Worku, 2008), at 55000 maize plants per hectare, the associated bean intercept 20% of light and yield was decreased by 70% compared to the sole bean.

Results showed that the genotypes affected significantly (p-value <0.001) bean yields. The variety G13607 produced (1468 kg ha^{-1}) as the same as variety AND10 (1036 kg ha^{-1}) and better than variety VCB81013 (1014 kg ha^{-1}).

According to ISABU (2009), regardless of the staking techniques used, G13607 and AND10 varieties perform well in terms of bean production in highlands conditions of Burundi. Furthermore, VCB81013 is a newly released variety, thus its genetic patrimony is not as stable as for AND 10 and G13607 varieties. There was no significant genotype by staking technique interaction for grain yield. Therefore, selection of common bean cultivars for staking with wood or strings could sufficiently identify suitable genotypes for intercropping with hybrid maize (Worku, 2008).

6. 2. Conclusion

Research is a complex activity that requires investment of both personnel and technical resources. Personal knowledge and expertise are very important in carrying out research activities. However inter-disciplinarity and trans-disciplinarity are very useful strategies of success while doing research. From the present study it has identified that team work, capacity building, and well designed research instruments are useful tools for successfully implementing research.

This internship at ISABU was devoted to improve research methods on plant breeding at ISABU. Therefore, review of research instruments and active participation in implementing some research projects constituted core achievements of this internship. Research instrument tools such as research protocol, questionnaire, proposals, and scientific report were designed in multidisciplinary teams.

The designing of proposals, protocols, and questionnaire in team contributed significantly in both team work development and proper planning research projects. For the most used research instrument tools such as protocol for experimental studies and scientific reports, both training and guidance in designing them were offered.

Data management usually is a long process that involves people from different background in terms of knowledge. Consequently, field research assistants and scientists received appropriate training sessions to enhance their specific ability in data entry or data analysis, respectively. Also, data entry screen and documented spreadsheets have been made to ease data entry, data archiving and data retrievable.

As a case study, this dissertation reported an on-farm experiment of evaluating the effect of three staking techniques on yield of climbing beans in highlands of Burundi. Results highlighted a significant effect of staking technique and genotype on climbing bean grain yield. The better performance of the staking climbing bean with both woods and strings could be attributed to better light distribution throughout their canopy as a result of their upright growth. Genotype effect is attributed to either well performance of AND10 and G13607 bean varieties in highlands conditions of Burundi or the stability of their genetic potential.

6. 3. Recommendations

From this one year attachment at ISABU research institute, research methods support offered led to recommend the following.

The culture of working in groups for research should be developed and take place from planning stage till findings publication. Questions that were supposed to be answered at planning stage were emerging at the implementation or data analysis stages.

Scientists should be sensitized on the fact that research is a complex activity that requires people with different backgrounds to work together. For instance, researchers should associate with a biometrician at all research stages rather than consult only when having challenges with data analysis.

Research institutes should have both data management and statistical services rather than rely on individual biometricians. During this internship most of the questions addressed were related to experimental design, data management and data analysis.

Research institutes should be provided with facilities such as internet and appropriate software. Well utilized, these facilities speed and empower quality in research designing, research implementation and publication of findings.

Publishers should facilitate access to scientific publications for institutions and researchers by making papers publicly available either in open-access journals or in open-access repositories.

There is a need of offering capacity building sessions for both scientists and field research assistants. Since research facilities like software are changing due to the profit-making of their manufacturer these capacity building sessions should be organized periodically and focused on use of statistical software as well as on scientific writing.

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APPENDICES

APPENDIX 1: GUIDE FOR WRITING A SCIENTIFIC REPORT

Definition

A scientific report is a written document that presents information by using short, concise paragraphs, graphics wherever possible (tables, graphs, illustrations). It aims to inform, as clearly and succinctly as possible. A report may need an abstract (sometimes called an executive summary) and does not always need references and bibliography. However it is often followed by recommendations and/or appendices (Burnard, 2004).

Basic outline of a scientific report

Although the format of a report is usually determined by audience, information, and purpose most reports have some or all of the following parts (SDC, 2000) : Title, Summary, Table of contents, Introduction, Materials and methods, Results, Discussion, Conclusions and recommendations, References, Acknowledgment and Appendices (if used).

1. Title page

This section normally carries the title, sub-title if any, date, author's name and position. It may also carry a reference number or other classification (eg, confidential). The page should not be overcrowd a clear, simple layout is always the best.

The title of a scientific report sums up the research work in a single phrase or sentence. Therefore, it needs to be clear, specific, and brief. First impressions are very important; therefore, a title must be prepared carefully. Scientists scan through journal article titles which they find using online journal databases. They decide which abstracts they will read based on the titles. The title should therefore sum up the experiments and findings in a single phrase, providing as much specific information as possible, in order to differentiate your work from the work of others. A title should be worded carefully, so that its meaning is clear to most readers (Robyn, 2008).

2. Summary

The abstract is a short paragraph summarizing the main contents of the report. It should include a short statement of the main task, the methods used, conclusions reached and any recommendations to be made. The abstract or summary should be concise, informative and independent of the report (Burnard, 2004).

Like the title, an abstract is usually written for a wider audience than the rest of the article. If attractively written, it may whet their appetite, and stimulate them to read the whole thing. Abstracts are usually written in past tense in a single paragraph. Since it is a condensed version of the full report, it is easiest to write the abstract last (Robyn, 2008).

3. Table of contents

This section should list all the main sections of the report in sequence with the page numbers they begin on. The contents of short reports may be shown on the title page. More extensive ones should always have a separate page. If there are charts, diagrams or tables included in your report, these should be listed separately under a title such as 'List of Illustrations' together with the page numbers on which they appear (Burnard, 2004).

4. Introduction

This gives a brief general background to the subject of the report, defines the limits of the report, outlines and shows why it was necessary. In other words, the introduction must state the research problem and research objectives clearly, describe the methods and results briefly, and state the major conclusions (Barnes, 2000).

The introduction is an opportunity to explain and define the research work, putting it into context. This is where to explain why your particular research problem is distinctive. The introduction should include a literature review, which provides general background information about what has already been published in your research area. It should provide adequate information about the research area, so that readers do not need to refer to other materials to understand the research problem (Robyn, 2008).

Since the research problem is stated, it is also important to describe how the work attempted to answer it, and to give the major findings and conclusions. The shorter the introduction is the better.

The introduction should be mainly written in the present tense, since you are describing a current problem and current conclusions (Robyn, 2008). Details of methods and results given in the introduction should be in the past tense, and future implications based on the conclusions should be in the future tense.

5. Materials and methods

The main purpose of the materials and methods section is to provide an extensive protocol for your experiment which can be repeated by others. Essentially the materials and methods section is an instruction manual; all workers in the field should be able to reproduce your experiments after they have read this section. Reproducibility is a fundamental tenet of good scientific research; therefore, the methodology must make reproduction a possibility, by providing the necessary details in this section (ACS, 2008). This section should be chronological and informative, providing details of the experimental design, data collection (recording) techniques, specific methods of the sample preparation and sampling protocols, etc...

Brief details of the statistical methods that were used, including the reason for their choice, should also be included (Robyn, 2008). This section is usually written in the past tense, since the activity has been completed.

6. Results

This is where the core of the work is presented. The results section should present data in a manner that is easy to read and interpret. Thus, clarity is essential since the rest of the report hinges on what is presented in this section. Findings are presented in as simple a way as possible. The more complicated the information looks, the more difficult it will be to interpret (Burnard, 2004). Discussion of the results implication is saved for the discussion section. This section may have subheadings which complement the headings in materials and methods part (Robyn, 2008).

Data is often presented outside the text, in tables or in figures. Tables are appropriate for presenting precise numerical data, whereas it is easier to identify a trend in a graph. Figures and tables are much easier to read and interpret if they stand alone, this can be achieved by including an appropriate title and a legend (Barnes, 2000). A predigested representative sample is usually adequate to present as results rather than raw data. Analyze and interpret data so that others can understand it. Ensure that statistics are meaningful, and provide p-values or and others measures of precision.

7. Discussion

The main purposes of the discussion section are to discuss the relationships between findings, discuss how the results relate to initial objectives and hypotheses, provide major conclusions supported with evidence, and suggest future applications of your research findings (Robyn, 2008).

This section is an opportunity for the investigators to discuss and show his (her) ability to understand research activity carried out. This is the section for interpreting results drawing from the information which you have collected, explaining its significance. Identify important issues and suggest explanations for your findings.

Outline any problems encountered and try and present a balanced view. Discuss how your results are similar or different from published findings, and attempt to explain any differences, with support from references. This is where relationships between each of results and principles that these relationships may demonstrate are discussed (Barrass, 1995).

Scientists are tempted to omit or adjust results that do not quite fit, rather discuss on all the results including negative or insignificant results. Ability of a researcher to explain any experimental anomalies, based on the established theories, is a skill that many scientists are looking for (Day, 1998 quoted in Robyn, 2008). Most of the discussion should be written in the present tense, and when you discuss future implications of your work, write in the future tense.

8. Conclusion and recommendations

This is the section of the report which draws together the main issues. It should be expressed clearly and should not present any new information. Reporter may wish to list recommendations in separate section or include them with the conclusions (Burnard, 2004).

9. References

The main purposes of the references are to acknowledge sources in order to avoid plagiarism, and strengthen your arguments with support from the existing literature. A scientific report should be well referenced. Every piece of information that is included in a report, excluding original data, should be referenced, preferably from peer-reviewed sources.

Arguments will be much stronger if they are supported with accurate and appropriate references. It is advisable to include references while actually writing. Tracking back to find references is an extremely difficult task (Robyn, 2008).

References are typically presented in scientific reports using the Harvard system, or a numerical system. However each referencing system should provide details on the following: other's name and initials, date of publication, title of the book (paper or journal), publisher, place of publication, page numbers, and details of the journal volume in which the article has appeared (Barnes, 2000).

10. Acknowledgment

Any help you have received in collecting the information for the report should be acknowledged. This is a section where the researcher thanks those who were directly involved either in implementing or supporting the work (Robyn, 2008). Since in the most reports this section tends to be very brief the researcher identifies those who provided most support and thank them appropriately.

11. Appendices

An appendix contains additional information related to the report but which is not essential to the main findings. This can be consulted if the reader wishes but the report should not depend on this. You could include details of interview questions, printouts of raw data, statistical data, a glossary of terms, or other information which may be useful for the reader (Burnard, 2004).

Different types of material included in the appendices can be labeled as Appendix 1, Appendix 2, Appendix 3, and so forth (Robyn, 2008).

APPENDIX 2: GUIDE FOR WRITING A RESEARCH PROTOCOL

Definition

Research protocol is a written description of everything that will be done in the experiment. A protocol should be written for every experiment and must be shared before the experiment starts to get input from others (Sanjay *et al.*, 2005). As a general guide, an orientation is provided on what the investigators are expected to develop for each component of the protocol. However the guidelines should not necessarily be applied rigidly. How they are applied will depend on the type of study and the methodological approach of each investigator.

Basic outline of a research protocol

1. Title page

The page contains the title of the project, names, roles and contact details of investigators, experts and advisors involved in the study, sponsor, and principal investigator's employer. Study site, technical departments and institutions involved in the study and protocol details (Version number, final/draft, date) are also written on this page. For the project title, a good title should be short, accurate, and concise. It should make the central objectives and variables of the study clear to the reader (reviewer), and specify what population or universe will be investigated (NHS, 2006).

2. Protocol summary

Summary should be concise but must be sufficient to orient the reader to the main purpose of the study (Sanjay *et al.*, 2005). It introduces the problem being addressed and highlights how the study would be conducted by describing the methods and procedures laid out in the chapter on methodology (NHS, 2006).

3. Statement of the problem

The paragraph states the research question and provides background information related to the topic. This constitutes the scientific justification for the study, the basis of the need for research to generate further knowledge that will contribute to existing knowledge. The statement must be written in a way that gives empirical references to describe the situation and also clearly specifies the gaps in existing knowledge of the problem. The problem statement should make a convincing argument that there is not sufficient knowledge available to explain the problem and its possible alternative solutions, or it should make a convincing argument for the need to test what is known and taken as fact. The following points must be taken into consideration while dealing with this section: Discuss the importance of the topic, review the relevant literature and current knowledge, describe any results already obtained in the area of the proposed study, indicate how the research question has emerged and fits logically, and explain how the study will benefit the community (Wilson and Abeyasekera, 2006).

4. Objectives

The study objectives emerge from the study questions. It indicates the specific approach towards answering the study question and is precise and measurable. The objectives should be Specific, Measurable, Achievable, Relevant and Time based (SMART objectives). Objectives must depict why the research is going to be carried out and what results are going to be achieved from the study (Sanjay *et al.*, 2005).

5. Methodology

The methodology explains the procedures that will be used to achieve the objectives. In this section the operational definition for the variables used should be specified in detail, along with the type of variables and the ways to measure them. In addition, the methodology should consider the study design and the techniques and procedures used to achieve the proposed objectives. The methodology should provide details of the experiment such as the data definition, the structure of the design, the method of data collection, and the type of analyses to be applied to the data.

Defining the experimental design consists of the following steps: Identify the experimental unit, identify the types of variables, define the treatment structure, and define the design structure, Randomization and layout, Data collection procedures, data management and statistical analysis (SAS, 2005).

5. 1. Experimental (or Sampling) Unit

The first step in detailing the data collection protocol is to define the experimental unit. An experimental or sampling unit is the person or object that will be studied by the researcher. This is the smallest unit of analysis in the experiment from which data will be collected. For example, depending on the objectives, experimental or sampling units can be individual persons, students in a classroom, the classroom itself, an animal or a litter of animals, a plot of land, patients from a doctor's office, and so on (SAS, 2005).

5. 2. Types of variables

A data collection plan considers how controllable variables (primary variables) and uncontrollable variables fit into the study.

Primary variables are the variables of interest to the researcher. Primary variables are independent variables that are possible sources of variation in the response. These variables comprise the treatment and design structures and are referred to as factors. Uncontrollable variables are those variables that are known to exist, but conditions prevent them from being manipulated, or it is very difficult (due to cost or physical constraints) to measure them. The experimental error is due to the influential effects of uncontrollable variables, which will result in less precise evaluations of the effects of the primary and background variables. The design of the experiment should eliminate or control these types of variables as much as possible in order to increase confidence in the final results (SAS, 2005).

5. 3. Treatment Structure

The treatment structure consists of factors that the researcher wants to study and about which the researcher will make inferences. The primary factors are controlled by the researcher and are expected to show the effects of greatest interest on the response variable(s). For this reason, they are called primary factors. Factorial designs vary several factors simultaneously within a single experiment, with or without replication. The treatment structure relates to the objectives of the experiment and the type of data that's available (SAS, 2005). Drawing a design template is a good way to view the structure of the design factors. Understanding the layout of the design through the visual representation of its primary factors help greatly to construct an appropriate statistical model.

5. 4. Design Structure

Most experimental designs require experimental units to be allocated to treatments either randomly or randomly with constraints, as in blocked designs.

Blocks are groups of experimental units that are formed to be as homogeneous as possible with respect to the block characteristics. Homogeneous clusters improve the comparison of treatments by randomly allocating levels of the treatments within each block. The design structure consists of those factors that define the blocking of the experimental units into clusters (SAS, 2005).

5. 5. Randomization and layout

Consider a plant breeder who wishes to compare the yield of new bean varieties. While setting up this type of experiment, treatments (varieties) must be assigned to experimental plots so that a particular treatment (variety) is not consistently favored or handicapped. This can be achieved by randomly assigning varieties to the experimental plots. Randomization ensures that each variety will have an equal chance of being assigned to any experimental plot and, consequently, of being grown in any particular environment existing in the experimental site (Gomez and Gomez, 1983).

5. 5. 1. Randomization of a RCB design using random numbers

Randomized complete block (RCB) design is one of the widely used experimental designs in agricultural research. The design is especially suited for field experiments where the number of treatments is not large and the experimental area has a predictable productivity gradient. The primary distinguishing feature of the RCB design is the presence of blocks of equal size, each of which contains all the treatments.

The randomization process for a RCB design is applied separately and independently for to each of the blocks. We use a field experiment with six treatments A, B, C, D, E, F and four replications to illustrate the procedure.

SPEP 1: Divide the experiment area into "**r**" equal blocks, where **r** is the number of replications.

STEP 2: Subdivide the first block into "**t**" experimental plots, where **t** is the number of treatments. Number the **t** plots consequently from **1** to **t**.

STEP 3: Assign the treatments to the experimental plots by using the following randomization scheme.

STEP 3. 1: By table of random numbers, locate a starting point in a table of random numbers by closing your eyes and pointing your finger to any position, and select six three digit random numbers. For this exercise, the appointed position is the intersection of the ninth row and third column of the bellow fragment of a table of random numbers. We start at that point and read downward vertically, to get the following:

Random numbers	Sequence
918	1
427	2
920	3
772	4
243	5
494	6

STEP 3. 2. Rank the random numbers from the smallest to the largest, as follows.

Random numbers	Sequence	Rank
918	1	5
427	2	2
920	3	6
772	4	4
243	5	1
494	6	3

Fragment of a table of random numbers

Row \ Col	C1	C2	C3	C4
R1	5950	5189	9374	7904
R2	2973	6405	1497	2863
R3	6081	7364	9081	2635
R4	9041	8475	3615	4093
R5	4208	9516	9530	7649
R6	9412	3642	7497	9735
R7	8480	5075	1804	4956
R8	5318	8749	9512	5408
R9	2094	6385	**918**5	2635
R10	3158	9753	4279	6496
R11	9082	3645	9202	3649
R12	5232	4146	7729	5584
R13	4252	7489	2434	2965
R14	2020	8895	4948	3072
R15	8392	6359	7040	5695

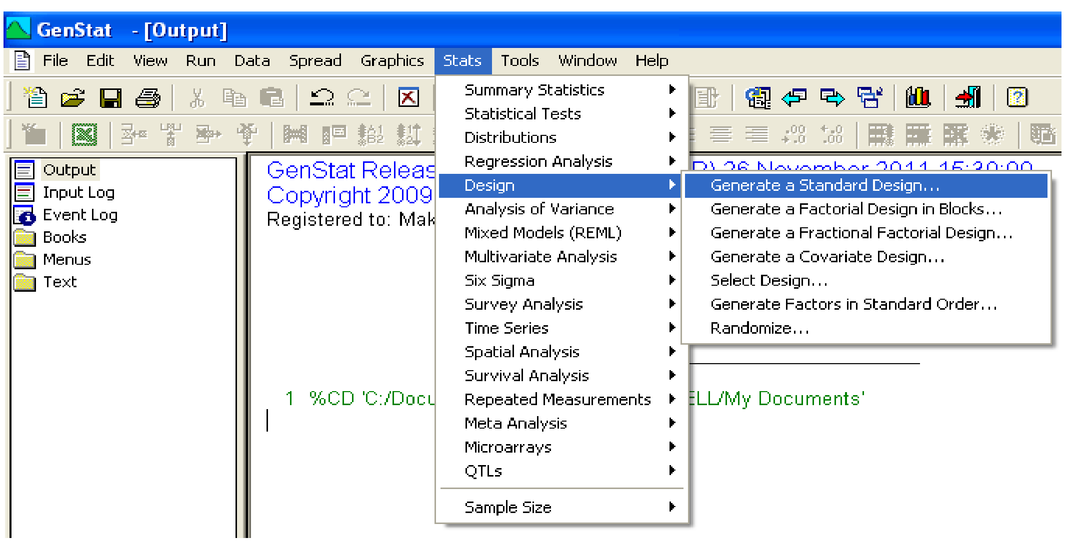
STEP 3. 4: Assign the six treatments to the six plots by using the sequence in which the random numbers occurred as the treatment number and corresponding rank as the plot number to which the particular treatment is to be assigned. Thus treatment A is assigned to plot 5, treatment B to plot 2, treatment C to plot 6, treatment D to plot 4, treatment E to plot 1, and treatment E to plot 3.

STEP 4: Repeat STEP 3 completely for each of the three remaining blocks.

5. 5. 2. Randomization of a RCB design using Gen Stat

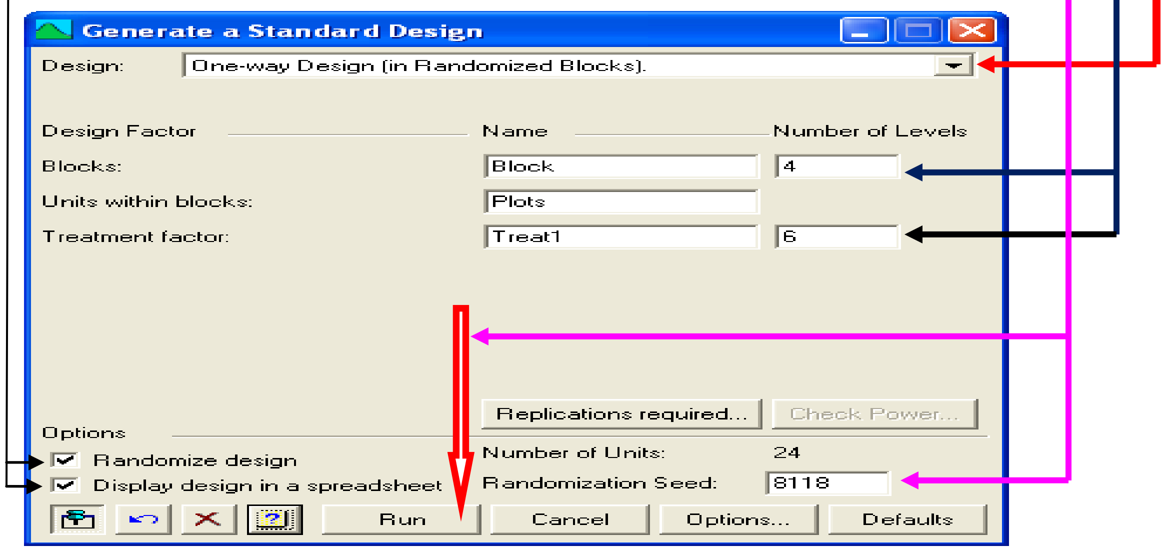
Currently any experimental design can be randomized using Gen Stat software. This is performed by using the following procedure:

- Stats ➔Design➔Generate a standard design

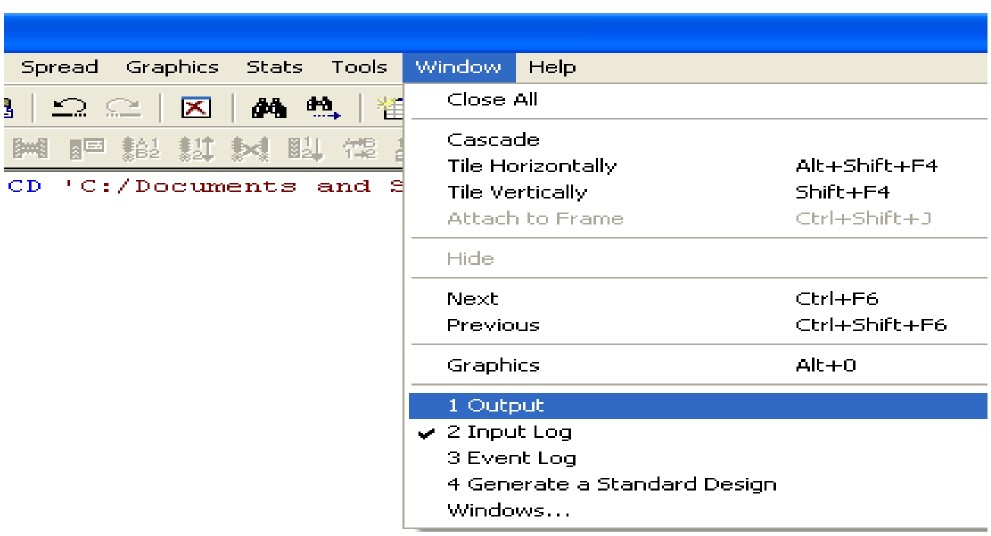


This opens up the following “Generate a Standard Design” box dialogue

- From the drop down list choose One-way design (in Randomized Blocks)
- Type 4 and 6 as Number of Levels of Blocks and Treatment factor , respectively
- Under options, Tick Randomize design and Display a design in a spreadsheet
- Leave Randomization seed as is, then click Run



- From the Menu, click on Window and select Output (Window➔ Output) to check the output of the task performed



The randomization procedure is displayed in both **output window** under "Treatment combinations on each unit of the design" and in a **Gen Stat [Spreadsheet; book…].** The table of "Treatment combinations on each unit of design" is used to assign at random treatments to experimental units (see the table below), while the "Gen Stat [spreadsheet; book..]" is used in designing data collection sheet.

Table: Treatment combinations on each unit of the design

Block	1	2	3	4
Plots				
1	5	6	1	1
2	6	1	3	4
3	2	3	2	2
4	4	2	6	6
5	1	4	5	3
6	3	5	4	5

Output interpretation

- ✓ Within Block 1: Treatment 5 is assigned to plot 1, treatment 6 to plot 2, treatment 2 to plot 3, treatment 4 to plot 4 , treatment 1 to plot 5, and treatment 3 to plot 6.
- ✓ Within Block 2: Treatment 6 is assigned to plot 1, treatment 1 to plot 2, treatment 3 to plot 3, treatment 2 to plot 4, treatment 4 to plot 5, treatment 5 to plot 6.
- ✓ Etc………..

5. 6. Data collection procedures

The protocol must state how the data will be collected to determine the outcome of the study. The investigator should write up the procedures that will be used, how and when the procedures will be used to collect information (Sanjay *et al.,* 2005). The protocol should have an annex containing the instruments that will be used (David, 2005): data collection sheets, questionnaire, interview guide, observation recording form, etc..

5. 7. Data management and statistical analysis

In accordance with the proposed objectives and based on the types of variables, the protocol specifies how the variables will be measured and how they will be presented (quantitative and/or qualitative), indicating the analytical models and techniques. In addition it highlights which variables will be used to assess groups comparability and how they will be reported (e.g. means, proportions), methods of analysis and how the results will be reported, when will the analysis be done and by whom. A briefly description on the software packages that will be used is also provided (NHS, 2006).

6. Expected outcome

This section restates the justification for the study in terms of the anticipated results. It will specify the implications of the potential results and how the results of the study may be useful to the policy makers, community at large and for future research (Sanjay *et al.,* 2005).

7. Budget summary

A brief outline of the budget requirement showing head-wise expenditure for the study should be given in this session. A detailed budget estimate showing all the expenditures under various heads can be placed in annex (Sanjay *et al.*, 2005).

8. References

In this section list of the various references quoted while formulating protocol may be written in a sequential manner (Sanjay *et al.,* 2005).

9. Annex

9. 1. Data collection forms: All the formats (data collection forms, questionnaires, etc) that may be used in the study should be placed in the annex as appendices in a systematic manner (Sanjay *et al.,* 2005).

9. 2. Budget details: Each item of expenditure expected for the conduct of the study must be specified along with a justification.

9. 3. Curriculum-vitae: This section should describe role of each investigator in the study, and state clearly who is responsible for each component of the study. The curriculum – vitae should provide a clear description of the qualification and experience of the investigators, including training, academic degrees or certificates, research experience and scientific publications (Sanjay *et al.,* 2005).

Appendix 3: EVALUATION FORM FOR SEMINAR AND TRAININGS

A. The content of the seminar was:

	5	4	3	2	1	
Extremely valuable	…	….	…	…	…	of little value
Detailed enough	…	…	…	…	….	too general
Current & relevant	…	…	…	…	…	outdated
Cohesive & logical	…	……	…	…	…	fragmented

NB: Evaluation levels 1= Excellent, 2= Very good, 3= Good, 4= Weak, and 5= Poor

B. The seminar presenter:

	5	4	3	2	1	
Was knowledgeable	….	…	…	…	…	was unsure of material
Had good presentation skills	….	…	…	…	…	had poor skills
Encouraged participation	…	…	…	…	…	discouraged participation
Addressed my level and needs	…	…	…	…	…	did not address them

NB: Evaluation levels 1= Excellent, 2= Very good, 3= Good, 4= Weak, and 5= Poor

C. The training materials (hand-outs):

	5	4	3	2	1	
Are excellent	….	…..	…..	……	……	are poor
Follow course content	……	……	……	……	…….	are disjointed
Are valuable for reference	……	……	……	……	…..	are of no value

NB: Evaluation levels 1= Excellent, 2= Very good, 3= Good, 4= Weak, and 5= Poor

D. Overall, the seminar:

	5	4	3	2	1	
Had clear goals	….	….	….	….	….	had unclear goals
Met its goals	….	….	….	….	….	missed its goals
Was long enough	….	….	….	….	….	was too short
Was excellent	….	….	....	….	….	was poor

NB: Evaluation levels 1= Excellent, 2= Very good, 3= Good, 4= Weak, and 5= Poor

E. What one thing will you do differently as a result of this workshop?

F. What was the most useful aspect of this seminar?

G. What would you suggest for improving the seminar?

H. Suggestions for future seminars:

I. General comments:

Appendix 4 EXAMPLE OF DATA COLLECTION SHEET WITH METADATA INFORMATION FOR FIELD EXPERIMENT

Metadata information

Study code	:	GIS./MUR./MOS./S.HA.2011.1
Study title	:	Comparative yield trial of bush bean varieties
Site	:	Moso, Murongwe, Gisozi
Scientist	:	Népomuscène NTUKAMAZINA, ndabanepo@yahoo.fr
Sponsor	:	ECABREN (Eastern and Central Africa Bean Research Network
Project title	:	Improving bean production and food security through selection of bean varieties for different agro ecological of Burundi
Objectives	:	Select bean varieties adapted to the 5 different agro ecological zones of Burundi
Design	:	Randomized Complete Block Design, 4 replications, experimental plot = 30 m^2
Treatments	:	12 bush bean varieties, 4 replications
Crop season	:	2011A

Treatment & Design structure				Responses variables or parameters											
Rep	Plot No	Plot	Treatment	Diseases scoring				Growth parameters				Yield components			
1	101	1	9												
1	102	2	12												
1	103	3	11												
1	104	4	10												
1	105	5	2												
1	106	6	6												
1	107	7	1												
1	108	8	3												
1	109	9	8												
1	110	10	7												
1	111	11	4												
1	112	12	5												
2	201	1	2												
2	202	2	6												
2	203	3	3												
2	204	4	4												
2	205	5	7												
2	206	6	5												
2	207	7	11												
2	208	8	1												
2	209	9	8												