SOME ISSUES ABOUT THE STATUS OF STATISTICS TEACHING IN AGRICULTURAL COLLEGES IN ARGENTINA

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SUMMARY

The status of Statistics teaching has not been sufficiently explored in Agricultural Colleges in Argentina. Although Statistics is considered as an important subject in different academic institutions, there is very little information about the way that it is taught in different university curricula. The aims of this study were to (a) gather information about the place of Statistics in college programs through different indicators, and (b) explore different issues concerning the teaching of Statistics in agricultural colleges, such as epistemological views, academic organization, etc. For this purpose, a survey was conducted in the main agricultural colleges in Argentina. Twenty-three teaching teams from different university answered a questionnaire. The responses were analyzed and categories were built in order to draw some conclusions.

Keywords: Agricultural Colleges; Statistics teaching; Survey

1. INTRODUCTION

Argentina is an extended agricultural and livestock production country with many universities granting degrees in Agricultural Studies.

Graduates from Agricultural colleges are mainly Agricultural Engineers - a word that has the same etymology as “genius” – and they have an active intervention in the interface between natural and social systems. These professionals are, above all, decision-makers, no matter whether they manage agribusiness companies, do research, teach, or work for public agencies or in the private sector. Their decisions are based on predictions that are heavily conditioned by uncertainty. This uncertainty is remarkable in agricultural activities as they rely mainly on climate factors, and biological and ecological natural processes, as well as on socio-economic variables. However, information reduces this uncertainty and provides decision makers with a framework that contributes to a better professional intervention.

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In the 20th century, Statistics was considered a fundamental scientific tool, and the basis for the experimental scientific method. Presently, Statistics may be found as a subject in different kinds of academic programs. Nowadays it is unconceivable to think of research projects without statistical support, thus this discipline is part of the curriculum in different programs at the undergraduate level studies- post-secondary programs leading to four-year degrees- and in post-graduate studies- more than one-year programs leading to specialist, master's or doctoral degrees. A sound, scientific culture demands training in statistical and probabilistic thinking, and rejects a single, deterministic data interpretation.

Statistics is an ever-changing scientific realm, and its teaching is mainly influenced by computer availability, and by the development of specific software. Neither the process of specific content learning, nor the development of calculation skills is the most important teaching aim. The teaching focus is placed on a specific way of reasoning that is deeply rooted in the idea that reality is viewed as a set of randomized phenomena. Data collection becomes useful only after a proper statistical analysis. Teaching statistical reasoning has to be considered only within this scope. Further, in Statistics the context of application (in this case, the agricultural sector) is the source of meaning for collecting, processing, and interpreting information.

This way of understanding reality enables professionals from different areas to manage sound concepts. Their decision-making processes are then supported by inductive inferences and statistical information, and are based on the critical reading of scientific publications, and on interdisciplinary research. Thus, teaching Statistics becomes a formidable challenge. Teachers should focus on thinking processes, interactive work, interdisciplinary projects, learning assisted by computing, etc. A primary goal of teaching Statistics is to enable students to render reasoned judgments about data, or about data interpretation, using multiple tools (Gal & Garfield, 1997, Cobanovic, 2002).

This study was carried out to explore and collect information about the status of Statistics teaching in Argentine agricultural programs. More specifically, the study aimed to (a) gather information about the place of Statistics in college programs, analyzing its resources, weaknesses, and strengths; and to (b) explore different issues concerning the teaching of Statistics in agricultural colleges, such as epistemological views, academic organization, etc. Smeeton (2002) carried out a similar study to collect information about teaching in undergraduate courses in dental statistics.

2. BACKGROUND

Towards the end of the 19th century, there was only one higher education institution in Argentina that specialized in the Agricultural Sciences, the "Escuela Superior de Santa Catalina" (1882), which then merged into the Agronomic and Veterinary Provincial School of La Plata (1890). In 1904, the "Instituto Superior de Agronomía y Veterinaria" was founded in Buenos Aires and then was annexed to the University of Buenos Aires. It was in this institution- now Facultad de Agronomía, Universidad de Buenos Aires- where formal studies in Statistics started in 1937. They were introduced as a second course of Mathematics in the Agricultural Engineering Program (Marotta, 1943).

In Argentina the teaching scenario is affected by the students' lack of previous statistical knowledge, course size, infrastructure, curriculum, and administrative structure of programs.

Teaching any discipline implies some underlying epistemological assumptions. In the case of Statistics, there is not a general agreement as to its epistemological nature, and authors have different approaches as regards its definition. The Merriam-Webster's dictionary (1995) defines to Statistics "as a branch of Mathematics dealing with the collection, analysis, interpretation and presentation of masses of numerical data". In her book, Batanero (2001) agrees with this idea: "*Notwithstanding its axiomatic foundation, Statistics may well be the only branch of Mathematics where debate is still going on about the interpretation of basic concepts*" (p. 9). Other authors consider Statistics as a set of methods or tools ready to be used in any context. Iversen (1992) states that Statistics is different enough from Mathematics, and that any Statistics course needs to be taught by a person having considerable experience with data and with the issues of statistical methods. In his opinion, such a course should have the aim to convey the nature of uncertainty and how seemingly random events have patterns to them; patterns that Statistics is created to look for. In addition, he establishes that it may be possible to define Statistics as a set of methods to study regularities in the face of variability. Some others, as Moore (1992), define Statistics as a science that has emerged as a discipline in its own right, that it is a subject in its own right. Even though Statistics is a mathematical science, it is neither a subfield of Mathematic nor merely a collection of methods that can be understood as ancillary to any substantive discipline such as psychology, business, or engineering. For these authors, Statistics has its own substance, its own distinctive concepts and modes of reasoning.

These definitions represent epistemological views that give rise to different teaching and research organizations within the academic institutions. These epistemological views can be analyzed not only through the definition of Statistics given by the teaching teams, but also through the bibliography they work with, the didactic strategies they use, and some other indicators. In addition, they can be indirectly studied through the faculty career paths, their research lines, and teaching profiles.

3. MATERIALS AND METHODS

A survey was conducted of all the universities having colleges that grant degrees in Agricultural studies in Argentina. Both public and private universities were involved in the study. The survey was conducted from August to December 2001. Due to great distances between the universities and our research center (Facultad de Agronomía, Universidad de Buenos Aires) most of the questionnaires were answered by e-mail. We surveyed the 27 agricultural colleges (see Table 1) by using a questionnaire that had 18 items relating to characteristics of the teaching teams, their academic and research activities, course organization, teaching methodologies, students' difficulties and teachers' definitions of Statistics.

Table 1. Agricultural Colleges in Argentina

Kind of University	ID(1)	University	Province
Public	1	Universidad Nacional de Catamarca	Catamarca
	2	Universidad Nacional del Comahue	Río Negro
	3	Universidad Nacional de Córdoba	Córdoba
	4	Universidad Nacional de Cuyo	Mendoza
	5	Universidad Nacional de Entre Ríos	Entre Ríos
	6	Universidad Nacional de Jujuy	Jujuy
	7	Universidad Nacional de La Pampa	La Pampa
	8	Universidad Nacional de La Plata	Buenos Aires
	9	Universidad Nacional de La Rioja	La Rioja
	10	Universidad Nacional del Litoral	Santa Fe
	11	Universidad Nacional de Lomas de Zamora	Buenos Aires
	12	Universidad Nacional de Mar del Plata	Buenos Aires
	13	Universidad Nacional del Nordeste	Corrientes
	14	Universidad Nacional de Salta	Salta
	15	Universidad Nacional de San Luis	San Luis
	16	Universidad Nacional de Santiago del Estero	Sgo. del Estero
	17	Universidad Nacional del Sur	Buenos Aires
	18	Universidad Nacional de Tucumán	Tucumán
	22	Universidad de Buenos Aires	Buenos Aires
	23	Universidad Nacional de Luján	Buenos Aires
	24*	Universidad Nacional de Río Cuarto	Córdoba
	25*	Universidad Nacional del Centro	Buenos Aires
	26*	Universidad Nacional de Rosario	Santa Fe
Private	19	Universidad del Salvador	Buenos Aires
	20	Universidad Católica de Córdoba	Córdoba
	21	Universidad de Concepción del Uruguay	Entre Ríos
	27*	Universidad de Morón	Buenos Aires

*ID stands for identification number. * These agricultural colleges did not respond to the survey.*

Twenty three out of the twenty seven chairs replied. The college academic unit is the chair, which contains both professors and teaching assistants. The questionnaire was addressed to the Statistics Chair Heads, who are responsible for the epistemological, teaching, research, and extension lines developed by their teams. The item dealing with Statistics definition was used to get information about the epistemological ideas supported by the chairs.

At first, the relations among variables were explored using exact chi-square tests. Agricultural Colleges were classified in groups by using hierarchical cluster methods using the quantitative variables. Cluster analysis was performed using the complete linkage method with Euclidean distances. No variable transformation was done. Further, a canonical discriminant analysis provided a representation of the populations found in the previous stage. SAS (1988) software was used for the analyses.

4. RESULTS

We first present the statistics teaching team characteristics as regards their academic background and activities in research and consulting work. Secondly, we place the subject Statistics within the Agronomy curriculum, its workload, and class size. Then, we discuss teaching methodologies, and in the fourth section we deal with common teaching difficulties. In the fifth section, teaching team opinions about Statistics definitions are analyzed, and finally university characteristics are presented by clusters.

4.1. CHARACTERISTICS OF STATISTICS TEACHING TEAMS IN AGRICULTURAL COLLEGES

Three Argentine colleges (among which there are two private ones) do not have teaching assistants, and one has no professors. Colleges with Agricultural Engineering Programs have 5 teaching members per chair in average, ranking from a minimum of 1 to a maximum of 10. Private colleges have a smaller number of professors and teaching assistants: in two cases there is only one professor per chair, and only three in the remaining one. In our opinion, the low number of professors is due to low salaries, which are paid by both public and private institutes.

In this study, an average of 43.6% faculty members per chair holds the degree of Agricultural Engineer. The number of these professionals per chair varies from 0 to 5 with a median of 2. This profession is the most frequently found across Statistics chairs, even though there are other related professionals, holding other degrees mainly in Biology, Mathematics, and Statistics. In only two of the chairs the professors have a degree in Statistics. As regards postgraduate studies, an average of 6% of the teaching team have Ph.D. degrees, minimum 0, maximum 4 (median = 0) and 28% have Master's degrees, minimum 0, maximum 3 (median = 1). Their postgraduate programs do not belong exclusively to the statistical area. In eight colleges there are no postgraduate degree holders and in ten, teachers having no postgraduate degrees lead teaching teams. Twelve out of the twenty three carry out consulting work and seventeen are involved in research activities.

The scarce number of teachers having a degree in Statistics is remarkable. The number of postgraduate degree holders is low, however, there is an increasing number of teachers taking postgraduate programs. Consulting work and research activities are closely related to full-time or part-time activities.

4.2. CHARACTERISTICS OF STATISTICS AS A CURRICULUM SUBJECT

Most of the students have their first contact with Statistics at the university level. In general, Agricultural College programs have one or two compulsory Statistics courses. In general, the first course deals with Statistics basic knowledge and the second with experimental design. Eighteen out of 23 colleges have their first Statistics course in the second year of their programs, comprising an average of 100 hours of work load (minimum: 64, maximum: 168). Only 7 colleges have a second Statistics course in their programs, comprising an average of 66 hours (minimum: 45, maximum: 90). This second course is taught in the second year in five colleges and in the fifth year in the rest. On the average, 76 students attend the first course (minimum: 10, maximum: 200). The second course has less students, averaging 39 (minimum: 12, maximum: 80). Personal computers are used only in 11 out of 23 colleges in the first course, and 3 out of 7 in the second one. Software programs mentioned were Infostat, Macanova for Windows, Excel, SAS, Statistica, Statistix, Statgraphics and SPSS.

In our opinion we consider that teaching Statistics before university may contribute the strengthening of concepts which can be later applied in professional careers.

4.3. TEACHING METHODOLOGY

Ten of the surveyed chairs teach theory and practice in an integrated way. For example, in the same teaching period they devote the first part of the class to the theoretical approach, and then proceed to practical aspects, such as solving problems, exercises, etc. The rest separate theoretical and practical classes.

All the chairs have more than one compulsory reading text. Fifteen chairs use textbooks, and at least one of them is related to Applied Agriculture or Biology. Fourteen chairs publish their own reading texts and one of the colleges has developed its own software. Seventeen different texts are mentioned. Di Rienzo et al (2000), Steel and Torrie (1986), Mendenhall (1990) and Walpole and Myers (1999) are given more than once.

Twelve out of 23 chairs work interdisciplinarily in the statistics course with other chairs, and 12 use overhead projectors. Only one chair organizes field trips.

From our standpoint, interdisciplinary work contributes to improve content integration by interpreting and solving real, agricultural problems. At Buenos Aires University, in our Statistics courses we worked together with the Plant Physiology Chair in designing and controlling different experiments.

4.4. TEACHING WEAKNESSES

Teachers often mention curricular and infrastructure difficulties as their main obstacle to teaching. As their courses are placed too “early” in the curriculum, students cannot understand the practical use of Statistics, and of the biological models being taught. Some teachers mention that other subjects demand too much from the students, so they cannot devote much time to Statistics. They also mention as obstacles uncomfortable classrooms, and the lack of availability of computing hardware and software. None of the private universities mentioned any infrastructure problems. Some faculty members consider that overcrowded classes, the students’ lack of interest, and of previous basic mathematical skills hamper their learning.

Sixteen chairs mention “probability” as one of the hardest topics, followed by the “tests of hypotheses”.

4.5. STATISTICS DEFINITION

Definitions were grouped in broad categories. Statistics in considered as:

(a) A branch of Mathematics;

(b) A set of methods or tools ready to be used in different contexts;

(c) An autonomous science;

(d) Other.

It may be of interest to illustrate some of the definitions given by the teaching teams corresponding to the three main categories:

Definition. (a): Statistics as a branch of Mathematics

La Plata College defined Statistics as: "*…a branch of Mathematics applied to information analysis".*

Definition (b):Statistics as a set of self-governing procedures for decision-making

Córdoba College defined Statistics as: "*...a discipline strongly based on Mathematics, having an engineering spirit, which approaches the problem of the collection and analysis of data, and the development of techniques to obtain information about systems generating a response with random errors".*

Catamarca College considered it as "*…a tool to provide the correct information, analyze it properly, and give inputs for decision-making (not setting aside common sense, though)".*

Similarly, Comahue pointed out: "*...is a set of methods backed up by probability theory for the treatment of information and decision-making*".

Salta stated *"Statistics is a discipline that provides tools, which are used not only to process large volumes of data and make them understandable, but which integrate the research process. It is also a tool that helps take more objective decisions. It provides a way to gather and analyze data accurately, contrast hypotheses, estimate parameters, and draw valid and reliable conclusions and recommendations within uncertainty".*

San Luis indicated: "*... is a set of methods that allows us to present and analyze information that may enable us to take decisions. It is related to mathematics in terms of probability theory*".

Universidad del Salvador considered it as: *"a set of criteria and tools useful for creating, analyzing, and interpreting valuable information for the development of production systems".*

Definition (c): Statistics as an autonomous science

Cuyo pointed out: *"from an applied perspective (...) it is a science that has an identity of its own, and provides tools for capturing real data, analyzing variability, drawing general conclusions based on probabilistic theory, and the communication of results*".

Mar del Plata stated: "*Statistics is an important aspect of research methodology as it contributes to: 1. Clarify the research problem. 2. Set the research objectives. 3. Plan the search for reliable information suited to the research problem and objectives 4. Process information through specific techniques 5. Interpret results within the context of the methodology used*".

Two of the chairs view Statistics mainly as a branch of Mathematics applied to information analysis -definition (a)- and eleven conceive it as a set of self-governing procedures for decision-making- definition (b)-. Nine teachers envisage it as a scientific dealing extracting information from numerical data -definition (c)-. The remaining chair has a contradictory answer. Agricultural Engineers lead the two chairs that gave definition (a). On the other hand, the two chairs led by Statisticians define Statistics as an autonomous science -definition(c)- and the three chairs led by Biologists consider it a set of tools- definition (b). No differences were observed as regards postgraduate studies (Chi-Square = 0.8, $p = 0.82$), neither in relation with the position of Head of the Chair (Chi-Square = 3.93, $p = 0.17$), nor with undertaking interdisciplinary courses (Chi-Square = 0.90, $p = 0.82$).

4.6. UNIVERSITIES CLUSTERING

Faculty teams were grouped by characteristics regarding the number of Ph.D. and Master's degrees, and the number of teachers working as advisers and researchers. Cluster analysis identified three clusters of universities in the dendrogram in Figure 1. The first cluster was made up by 13 colleges, including the private ones. They have a low number of members and scarce postgraduate background (only one Ph.D. within the group), and only a few of them provide technical advise and work on research projects. The second cluster comprises only one college that has a high number of teachers holding Ph.D. and Master's degrees, and all of them are members of advising and research programs. The third cluster, made up of 9 colleges, presents a medium level of postgraduate degrees, working in consulting activities and doing research work. The first canonical variable in the canonical discriminant analysis can explain 83% of the total variance. This variable appears to be largely influenced by the variables related to the degree reached by the members of the chair (Table 2). The second canonical variable is positively influenced by the number of professors and inversely related to the number of Ph.D. degrees. The three clusters can be easily discriminated by the first and the second canonical variables. The plot of scores of canonical variable one against canonical variable two is shown in Figure 2. This confirms the same grouping identified in the dendrogram. There is a clear separation of the second cluster (Universidad de Córdoba) with high values on canonical variable one and high negative value on canonical variable two.

Table 2. Raw canonical coefficients

Variable	Canonical variable	
	1	2
Number of professors	0.732	0.690
Number of assistant teachers	-0.079	0.246
Number of Ph.D.	1.759	-1.973
Number of Master	0.954	0.497
Number of teachers doing consulting	0.462	0.030
Number of teachers doing research work	0.313	0.260

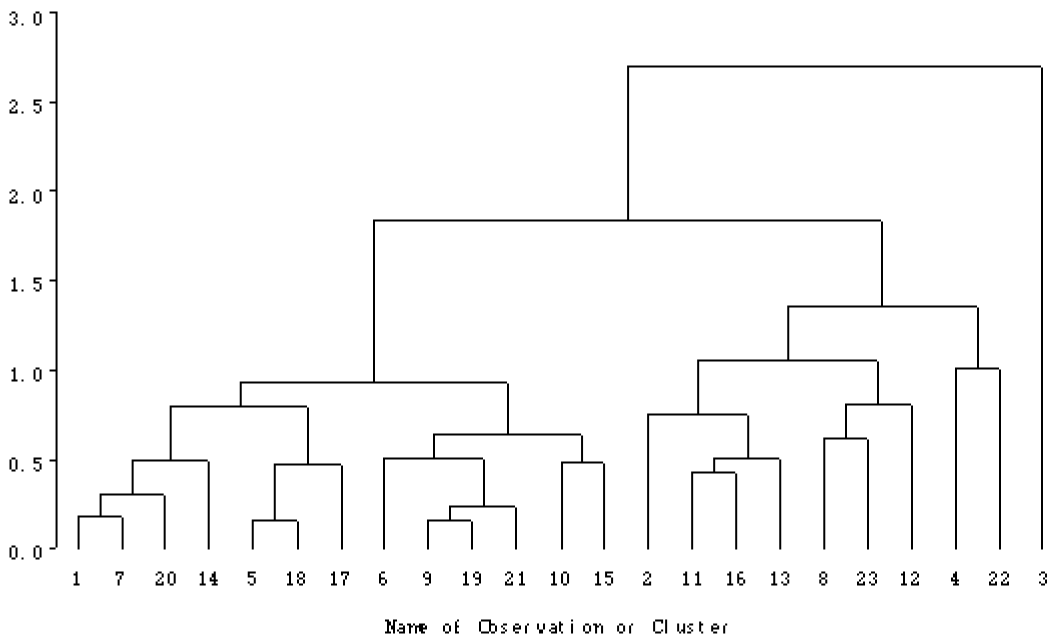
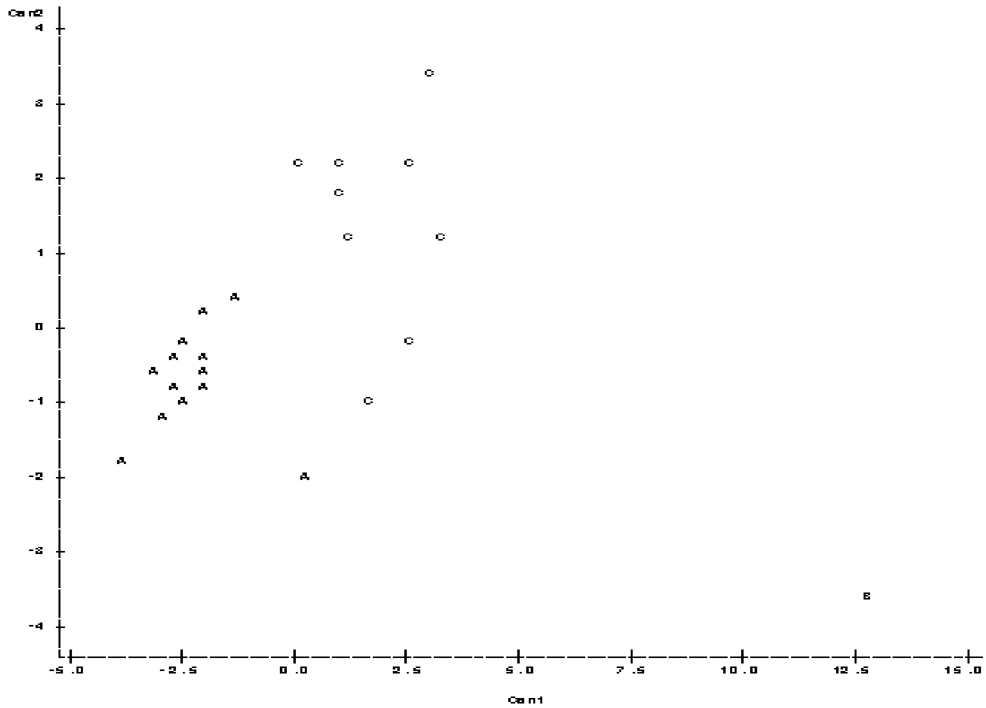


Figure 1. Dendrogram for the twenty-three universities



First, second and third clusters are indicated by the letters A, B and C, respectively.

Figure 2. Plot of the twenty three universities for the canonical variables

5. DISCUSSION

The need to get information about the status of teaching statistics in Argentine Agricultural Colleges was the main purpose of this study. In analyzing the results, we notice that some characteristics are homogeneous, such as the use of more than one compulsory reading texts, some related to Agriculture or Biology. In almost all colleges inadequate infrastructure was mentioned as a major barrier. In some cases, it is not possible to use computers in class. Teachers also mentioned that as the courses are too early in the curriculum, students cannot understand the practical use of Statistics. Cobanovic (2002) points out the same problem. Other countries having no infrastructure restrictions seem to have the same problems. Magel (1996) states that student motivation is perceived to be a problem in the class. However, she mentions some techniques which pose interesting challenges for teachers, and improve teaching results without affecting costs. The teaching team characteristics did not seem to have any impact in teaching methodology. Ten chairs are managed by teachers having no postgraduate degrees.

In most of the colleges, probability and random variables are the topics that present most difficulties for students. In a further study, it would be interesting to explore the didactic strategies used in teaching them. Only twenty-three colleges were differentiated as regards the number of teachers, the postgraduate degrees, and the number of teachers involved in technical advice and research. These characteristics do not reflect the teaching methodologies, the difficulties reported, nor the epistemological ideas underlying the Statistics definition. The definition of Statistics as a branch of Mathematics was less popular as only two colleges held it. Curiously enough, the professors of those chairs of Statistics are not Mathematicians but Agricultural Engineers. The rest of the universities mainly consider Statistics either as a set of tools or an autonomous science. All the chairs led by Biologists defined Statistics as a set of tools, whereas all the chairs led by Statisticians defined it as a science. We did not observe any differences as regards the teaching team's undergraduate and postgraduate studies.

Córdoba University differed from the rest since it has a chair with many professors and assistants, and all its members but one have a Master's or Ph.D. degree, all provide advisory services and do research, and have developed statistic software and a manual.

In a future study, it would be interesting to contrast these findings, which are mainly concerned with teaching processes and organization, with the students' learning processes to assess students actual achievements.

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APPENDIX: QUESTIONNAIRE FOR STATISTICS TEACHERS
(UNDERGRADUATE AGRICULTURAL PROGRAMS)

1) University: ....…
Type: (check) Public .... Private: ....…
City: ....…
Province: ....…
College(or academic unit): ....…
Program: ....…
Chair /Department: …………………………..

2) Does the Chair/Department provide classes only to this program? (check)
Yes .... No ....

3) If your answer is negative, state whether it provides classes only to the agricultural area.
Yes .... No ....

4) Faculty:

Position	Full-time (F) Part-time (P) Simple (S) (1)	Grade	Post-graduate

(1): Full-time (about 40 hs per week); Part-time: (about 20 hs per week); Simple (about 10 hs per week).

5) How many teachers in the Chair/Department have taken Postgraduate courses about teaching Statistics?..
Mention the courses: ....

6) How many teachers in the Chair/Department work as agricultural consultants?
....

7) How many teachers in the Chair/Department carry out interdisciplinary research activities in agricultural areas? …………………………………

8)

	Course (1)	Year (2)	Hours (3)	Number of teachers	Course size (4)
1					
2					
3					
4					

(1): Mandatory courses related to Agricultural Sciences
(2): Year in the curriculum
(3): Total hours in the term
(4): Mean number of students per class.

9) Teaching Methodology:
Classes may be described mainly as (check)

Course	Theoretical-Practical	Theoretical and Practical (in different sessions)	Only theoretical	Only practical
1				
2				
3				
4				

10) Students have to read (check)

Course	No reading	Manual *	Notes prepared by Chair	Papers	Other (state)
1					
2					
3					
4					

* State author/s name:

11) State the percentage of class exercises which need a PC to be solved?

Course	%	Number of Students per PC	Software
1			
2			
3			
4			

12) Other teaching media: (overhead projector, videos, etc.) State:
....

13) If you work interdisciplinarily, state the disciplines you work with:
....

14) State the main teaching drawbacks:
....

15) List three topics causing learning difficulties:
....
....
....

16) Statistics is ... (check):
(a) a branch of Mathematics applied to information analysis…..
(b) a set of self-governing procedures for decision-making ……
(c) a scientific method for extracting information from numbers ….
(d) Other (state) ....