



The status of teaching plant nematology to undergraduate agronomy students in Argentina, Chile, Paraguay and Uruguay

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HIGHLIGHTS

- Teaching nematology is unsatisfactory in most agronomy schools in Argentina, Chile, Paraguay and Uruguay.
- Several factors contribute to this status, with their relative importance varying among the countries.
- Small student course load is the major reason for the lack of training in plant nematology.
- Chile and Paraguay seem to have the worst status, with several schools not providing compulsory classes in nematology.

ABSTRACT: In recent decades 'modern' agriculture has expanded into large areas of Latin American countries. The intensification of land use, with monocropping or fixed rotation schemes, has contributed to an increase in yield losses due to plant-parasitic nematodes. Thus, proper training in nematology for agronomists has become crucial to sustain food, fiber and bioenergy production. Through responses to a questionnaire received from nematology professors (NP) in Argentina, Chile, Paraguay and Uruguay, it has become clear that nematology teaching (NT) is unsatisfactory in many agronomy schools. Of major concern, detected by this survey **1)** a relatively low degree of graduate education among NP, **2)** little or no involvement of most NP in nematology research, **3)** too little nematology training of the students, expressed in class-hours, in the compulsory coursework, and **4)** several issues, raised by the NP, that hinder improvements in NT. In these circumstances, the authors believe that only a concerted action involving nematologists and scientific societies involved with plant protection in those countries will be able to improve NT for agronomy students in the short- to mid-term.

Keywords: training, agronomists, survey, education.

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INTRODUCTION

Cobb^[1] may have been the first nematologist to express concern about the quality of nematology teaching (NT). In an authoritative speech, he stated that “zoological textbooks give nemas [nematodes] inadequate treatment – treatment altogether disproportionate to their scientific and practical importance; the space devoted to nemas is insufficient, while many of the statements are antiquated or erroneous”. Since Cobb, our knowledge about nematodes has increased markedly; the number of scientists dedicated to studying these invertebrates has also increased dramatically, with many of them being specialized in the field of plant nematology. This field has arguably experienced the greatest development during the last 75 years. The existence of at least 15 national or transnational



nematological societies^[2] dedicated to plant nematology testifies to its strength. The negative economic impact of plant-parasitic nematodes on many crops worldwide has long been recognized by agricultural scientists and growers, at least by those who have experienced heavy economic losses.

Nonetheless, there remains among plant nematologists the perception that NT is shallow for most students in agricultural sciences. While a few nematologists have expressed concern about NT at the graduate level in the US and Europe^[3, 4, 5, 6], in underdeveloped and developing countries concern should be directed mainly towards proper NT for students at secondary / technical schools and on undergraduate courses. Indeed, upon graduation most agri-technicians, agronomists and forest engineers are unaware of the main plant-parasitic nematodes and their damage, and are unable to advise growers on even the most basic, practical aspects of nematology.

In Brazil, as part of a concerted action to improve NT for future agronomists, Souza et al.^[7] have analyzed questionnaire responses from nematology professors (NP) affiliated with 92 agronomy schools. Although data obtained through voluntary responses to questionnaires may express a better-than-real situation, no other approach was feasible to assess NT in the agronomy schools spread across Brazil, which now exceed 220^[8]. Briefly, NT is conducted mainly by professors who are *not* nematologists - most are plant pathologists whose nematology background was acquired in a single graduate course during their masters or doctoral studies. In nearly 60% of the schools the course-load dedicated to nematodes is only 5-10% of the class-hours dedicated to plant pathology. Of greatest concern, half of the NP considered this course-load to be appropriate for their agronomy students, while the other half listed several key nematology topics for which they acknowledged are not being taught properly; these include soil nematode distribution and sampling, taxonomy, ecology, epidemiology and management. Following this study, the Brazilian Nematological Society^[9] has distributed free NT-supporting materials to over 130 registered professors nationwide, notably the slide show *Introduction to Nematodes*^[10], produced by Ed C. McGawley et al. and adapted for Portuguese readers by Deborah Xavier and Janete Brito.

Due to historical and cultural determinants, its large dimensions and its distinct language, in many aspects, Brazil stands apart from Spanish-speaking South and Central American countries. Therefore, to gain insights into NT in Spanish-speaking countries, the questionnaire used in Brazil was translated into Spanish and sent to all of the agronomy schools in Argentina, Chile, Paraguay and Uruguay. The authors' hypothesis was that this investigation would unveil a situation of even greater concern regarding NT in these countries than in Brazil, due to the relative scarcity of nematologists and plant pathologists. The responses obtained and some conclusions are presented in this work. Whenever appropriate, data from Brazil obtained by Souza et al.^[7] is cited and put into perspective the analysis of the survey from South America.

MATERIAL AND METHODS

The questionnaire (see below in italics) was prepared to assess **1)** the NP's educational background and professional duties; **2)** how nematology is taught; **3)** the NP's own evaluation of their classes; **4)** the nematology topics which should be improved in their classes, if any, and **5)** their opinion on the appropriate format for NT-supporting material to be produced.

This questionnaire aims to assess nematology teaching (NT) to agronomy undergraduate students in Latin America. It should be answered by all professors involved with NT in your school. The answers will be considered for statistical purposes only, and there is no intention to judge right from wrong. The identification of the respondents is solely to avoid duplications; the respondents will not be identified upon publication of the results. Please, answer the questions precisely. Thank you for your participation.

Your name:

Your school:

1) What was your major in undergraduate studies?

Agronomy

Biology

Other. Specify:

2) What is your highest graduate degree?

Specialist (*Lato sensu*)

Masters

Doctorate / PhD

I don't have a graduate degree (go to question #4)

3) What was the research focus of your graduate studies (highest degree)?

- Mycology (plant path)
- Bacteriology (plant path)
- Virology (plant path)
- Nematology (plant path)
- Plant protection
- Agronomy (not plant path or plant protection)
- Zoology
- Other. Specify:

4) What are your duties?

- Undergraduate and/or graduate teaching only (go to question #6)
- Teaching and extension only (go to question #6)
- Teaching and occasional research (go to question #5)
- Teaching and active research (go to question #5)

5) If research is part of your duties, what is the focus of your projects?

- I work exclusively on mycology (plant path)
- I work exclusively on bacteriology (plant path)
- I work exclusively on virology (plant path)
- I work exclusively on nematology (plant path)
- I work with different groups of pathogens (I'm a generalist)
- Zoology
- Other. Specify:

6) In the compulsory coursework of your agronomy school, nematology

- Is taught as part of a plant pathology or zoology course
- Is taught as a course on its own
- It is not taught

7) In the elective coursework of your agronomy school, nematology

- Is taught as part of a plant pathology or zoology course
- Is taught as a course on its own
- It is not taught

8) How many class-hours of nematology are taught in your agronomy school,

a) In the compulsory coursework?

b) In the elective coursework?

9) What is the proportion between nematology and plant pathology course loads in the compulsory coursework?

- about 5%
- about 10%
- about 15%
- about 20%
- about 25%
- about 25-35%
- above 35%

10) How do you evaluate NT in your school?

- Appropriate (go to question #16)
- The course-load is excessive; it should be reduced (go to question #16)
- Not appropriate; it needs improvements (go to question #11)

11) Why NT is not appropriate? (you may mark more than one)

- I'm not motivated to improve it (there is no professional or economic reward for doing it)
- Most students are not cooperative and do not value my efforts to teach nematology
- Few students are motivated to study microorganisms / invertebrates, including nematodes
- I don't improve NT because I dislike this field / I don't feel confident to teach it
- The course-load assigned to NT is much reduced, which forces me to go through nematology topics quickly and superficially
 - I don't have the necessary time to update / improve the content of my nematology classes
 - It is difficult to stay updated on several nematology topics or to obtain new audio-visual resources
 - The school facilities are poor (problems in classrooms, audio-visual resources, library; no availability of transportation for field classes etc.)
- I'm unable to offer lab / practical classes on most nematology topics, which makes the course uninteresting to students

Other. Specify:

12) Which nematology topics need improvement in your classes? (you may mark more than one)

Introduction to nematodes, their importance to science, the environment, human and animal health and agriculture

Morphology and function of nematodes

Nematode soil distribution, sampling strategies and methods, processing of samples

Taxonomic identification to genus and species levels

Systematics of nematodes

Ecology of plant-parasitic nematodes

Epidemiology of plant-parasitic nematodes

Management strategies and methods

Use of entomopathogenic nematodes against plant pests

Other. Specify:

13) To improve my nematology classes, I'm willing to

Use more / new audio-visual resources only

In addition to using more / new audio-visual resources, I'm also willing to go through reviews and articles to update my nematology classes

In addition to the options above, I'm also willing to increase the nematology course-load

14) The e-book *Agricultural Nematology*, under preparation by the Brazilian Nematological Society, will provide NT-supporting materials. How should it be organized?

Texts and images that I'll use according to my needs (go to question #15)

Texts and images organized in ready-to-use classes in PowerPoint® (go to question #16)

15) The texts

should be more general, in Spanish, to make it easier to update class content

should be more specific / detailed - reviews and book chapters, even in English – from which I'll obtain information to update the class contents

16) Is there any aspect of NT in your agronomy school which has not been dealt with in this questionnaire? Specify:

Through contact with education officers, the course coordinators of all agronomy schools were identified and introduced to the objectives of this study. The questionnaire was sent directly to NPs or forwarded to them by the course coordinators. After five months, the responses obtained were analyzed.

RESULTS AND DISCUSSION

Of the 33, 19, 7 and 1 agronomy schools that exist in Argentina, Chile, Paraguay and Uruguay, respectively, responses were obtained from 49, 32, 57 and 100%, respectively (Table 1). For Uruguay, the percentages presented hereafter are only moderately useful, because there are only two NP in the single agronomy school in the country.

In Chile, Paraguay and Uruguay all NP are agronomists, while in Argentina the rate falls to 82%, with some biologists (12%) and zoologists (6%) being in charge of NT. The degree of graduate education of the NP varies considerably among the countries. Chile has 43 and 57% of the NP with a doctorate or masters degree, respectively. In Argentina, these rates fall to 41 and 29%, respectively. Eighteen percent of the Argentinian NP have a specialist / *lato sensu* graduate degree only, while 12% have no graduate degree. In Paraguay, 75 and 25% of the NP have a masters or specialist / *lato sensu* degree, respectively, while in Uruguay one NP has a masters degree and the other has no graduate degree. One may assume that the desirable investment in graduate education of the NP would probably benefit NT in all four countries.

Fortunately, among the NP who pursued graduate studies, most conducted their dissertation or thesis on a nematology topic, or in a field related to it. In Chile, 43% of the graduate NP conducted their research on nematology, and 43% on plant pathology (mycology or bacteriology). In Argentina, 47% conducted their dissertation or thesis on nematology, while 40% researched on a zoology topic, 6% on plant protection and 7% on plant pathology (mycology). In Paraguay, the proportion is 75 and 25% for plant pathology (mycology) and plant protection, respectively, while in Uruguay both NP are plant virologists. As happens in Brazil^[7], most agronomy schools may not see the need – or have the means - to hire more than one or two plant pathologists to fulfill the teaching needs of the students.

Table 1. Agronomy schools from which responses were received to assess the status of nematology teaching to undergraduate students, in Argentina, Chile, Paraguay and Uruguay.

Country	University
Argentina	Universidad Nacional de Buenos Aires
	Universidad Nacional del Nordeste
	Universidad Nacional de La Plata
	Universidad Nacional de Cuyo
	Universidad Nacional del Litoral
	Universidad Nacional de Entre Ríos
	Universidad Nacional del Sur
	Universidad Nacional de Córdoba
	Universidad Nacional de Lomas de Zamora
	Universidad Nacional de La Pampa
	Universidad Nacional del Centro de la Provincia de Buenos Aires
	Universidad Nacional de Jujuy
	Universidad Nacional de Rosario
	Universidad Nacional de Comahue
	Universidad Nacional de Mar del Plata
Universidad Nacional de Santiago del Estero	
Chile	Universidad de Chile
	Pontificia Universidad Católica de Chile
	Universidad Católica del Maule
	Universidad Católica de Temuco
	Universidad de Tarapacá
Paraguay	Universidad de Talca
	Universidad Nacional de Asunción
	Universidad Nacional de Pilar
	Universidad Nacional de Itapúa
Uruguay	Universidad de San Carlos
	Universidad de la República

With fewer plant nematologists graduating than plant virologists, mycologists and bacteriologists, most NT is conducted by other specialists.

It is widely believed that for university-level professors the involvement in research is beneficial for teaching. In Argentina, 82% of the NP declared themselves to be actively involved in research. Six percent reported being occasionally involved in research and 12% have teaching as their only duty at the agronomy school. In Paraguay the proportion is 50, 25 and 25%, respectively. In Chile all NP research actively, while in Uruguay one NP research actively and the other occasionally.

For university-level professors, one may assume that conducting research and teaching in the same field favors the regular update of content and audio-visual resources. Hence, it is believed that NP who are at least partially involved in nematology research are more likely to attend meetings, subscribe

to or access journals, and feel motivated to transmit the latest research in this field to students. In Chile, 29% of the NP focus their research projects exclusively on nematology. Twenty-nine percent consider themselves as being generalists – they switch between groups of plant pathogens. Twenty-one percent of the NP act as mycologists and 7% as bacteriologists. Fourteen percent declared that they focus exclusively on biological control of plant diseases. It seems therefore, that after concluding their graduate studies in nematology at least 1/3 of the Chilean nematologists switch to research on other groups of plant pathogens or on biological control of plant diseases. Most probably, the lack of faculty positions in nematology drives this change because NP must meet the profile required by the agronomy school.

In Argentina, only about 20% of the NP focus their research on nematology, as opposed to 60% on zoology and 7% on mycology. Thirteen percent consider themselves as generalists or act in integrated plant disease management. Apparently, more than half of the Argentinian nematologists switch to zoology research as they find an academic position.

Unfortunately, in Paraguay and Uruguay no NP conduct research exclusively on nematology. In the former, 33% of the respondents consider themselves zoologists and 67% are generalists. In the latter, both professors research on plant viruses.

Nematology training should be an integral part of agronomy students' education. Therefore, it should be taught in the compulsory coursework. Additional training in nematology is desirable through elective courses. In Argentina, all schools teach nematology within compulsory zoology or plant pathology courses. In 85% of the schools no elective course further details nematology. In Chile, 70% of the schools teach nematology within plant pathology or zoology courses, while 30% leave nematology out of the compulsory coursework. This must cause a significant weakness in the plant pathology training of future agronomists. On the other hand, 43% of the Chilean schools offer elective nematology classes.

In Paraguay, 25% of the agronomy schools leave nematology out of the compulsory coursework, while 75% teach it within zoology or plant pathology courses. Elective training in nematology can be obtained by Paraguayan students in 75% of the schools. In Uruguay, the single agronomy school offers nematology training as part of plant pathology courses, and nematology is not taught in elective courses.

On average, nematology is taught for 4.5 class-hours in the compulsory coursework in Argentina and Chile, and 6.0 in Uruguay and Paraguay. Certainly this is too low to give proper training to future agronomists that may face challenging circumstances presented by plant-parasitic nematodes. In comparison, the average course-load in Brazil is 12.8 class-hours in the private schools and 16.1 class-hours in the public schools^[7], which is also considered unsatisfactory.

This unsatisfactory training can also be expressed by the course-load dedicated to nematology in relation to plant pathology. In Argentina, NT comprises only 5% of the course-load dedicated to plant pathology in 70% of the agronomy schools, with some schools presenting a proportion of 10-20%. The weighted average was 7%. In Chile, Paraguay and Uruguay the course-load weighted averages were 10, 8.8 and 7.5%, respectively, while in Brazil it reached 10.5%^[7].

The answers given by many professors also express the unsatisfactory nematology training of agronomy students. Indeed, 47% of the Argentinian NP consider their nematology classes to be inappropriate for their agronomy students, although 53% consider them satisfactory. In Chile, the dissatisfied NP sum 70%, in Paraguay 25% and in Uruguay 50%. When asked why their classes are not appropriate, several problems were listed, with distinct frequencies reflecting distinct realities and perceptions among the NP from different countries (Figure 1). When asked which nematology topics need improvements in their classes, most of the nine options were marked; the five most frequently cited are shown in Figure 2 (Paraguayan NP listed only four topics). In Brazil, more than half of the NP listed four or more topics in need of improvement^[7]. Hence, there is little doubt that NP in the five countries need motivation and support to update and improve their nematology classes.

The willingness to get engaged to improve NT was assessed among the NP who were dissatisfied with their classes. In Argentina, 42% of them were solely willing to use more / new audio-visual resources, while 50% felt also inclined to go through reviews and articles to update the course content. Only 8% considered the possibility of also increasing the nematology course-load. This seems conflicting with the 32% of dissatisfied Argentinian NP who considered the low course-load one of the main problems affecting NT. Possibly they recognize the problem but are constrained by the difficulty of increasing the load of plant pathology or zoology courses due to the excessive number of class-hours that agronomy students must attend to graduate.

In Chile, 40% of the NP were willing to use more / new audio-visuales, 20% added more reading and 40% would also increase the course-load. In Paraguay all NP would update their audio-visual

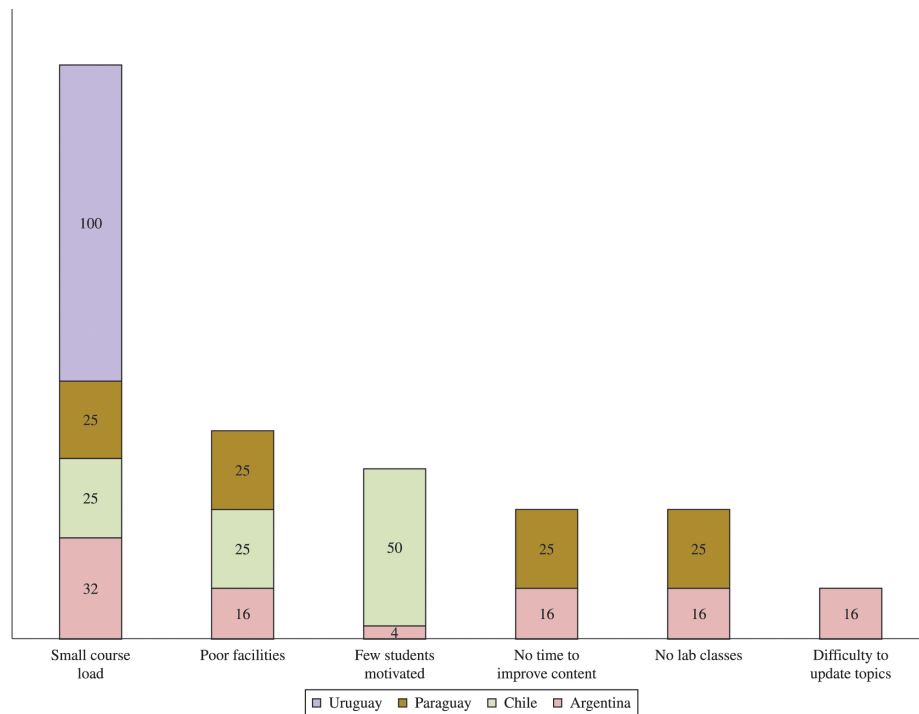


Figure 1. Relative percentage (indicated in the bars) of issues raised by professors in Argentina, Chile, Paraguay and Uruguay that contribute to their feeling of inappropriateness towards the nematology classes they teach to undergraduate agronomy students. In the questionnaire, the issues read as: the course load assigned to NT is much reduced, which forces me to go through nematology topics quickly and superficially; the school facilities are poor (problems in classrooms, audio-visual resources, library; no availability of transportation for field classes, etc); few students are motivated to study microorganisms / invertebrates, including nematodes; I don't have the necessary time to update / improve the content of my nematology classes; I'm unable to offer lab / practical classes on most nematology topics, which makes the course uninteresting to students; it is difficult to stay updated on several nematology topics or to obtain new audio-visual resources.

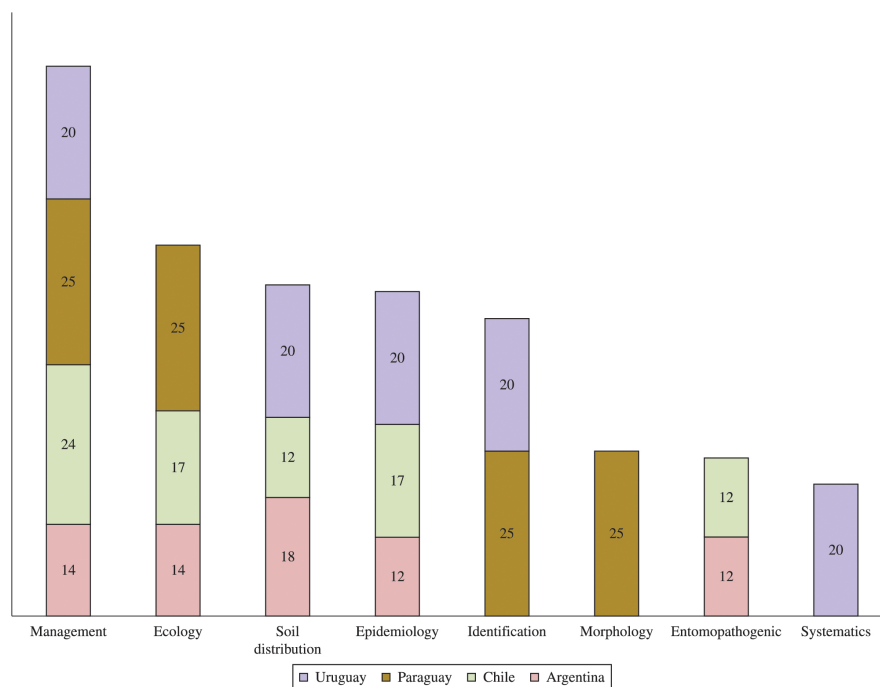


Figure 2. Relative percentage (indicated in the bars) of the topics most cited by professors which need improvement in the nematology classes they teach to agronomy students in Argentina, Chile, Paraguay and Uruguay. In the questionnaire, the topics read as: management strategies and methods; ecology of plant-parasitic nematodes; nematode soil distribution, sampling strategies and methods, processing of samples; epidemiology of plant-parasitic nematodes; taxonomic identification to genus and species levels; morphology and function of nematodes; use of entomopathogenic nematodes against plant pests; systematics of nematodes.

resources and do some reading, while in Uruguay both professors would go further to increase the nematology course-load.

When asked to suggest the structure of the upcoming e-book *Agricultural Nematology*, 63% of the Argentinian NP were interested in texts and images that they would use according to their needs, while 27% were interested in ready-to-use classes in PowerPoint®. In Chile, Paraguay and Uruguay the proportions were 80 / 20, 0 / 100 and 100 / 0%, respectively. Among the Argentinian NP who favored the e-book structured with texts, 43% would enjoy reading it in Spanish, with more general content to update the nematology classes easily, while 57% would enjoy reading more detailed reviews or book chapters, even in English, from which they would extract information to update their classes. In Chile, Paraguay and Uruguay, the proportions were 25 / 75, 100 / 0 and 0 / 100%, respectively. Collectively, these data do not offer clear guidelines for the structure of the upcoming e-book or other teaching-support materials. Most likely, the nematology background of the NP and their enthusiasm and time available to update their classes will ultimately determine their use of whatever supporting materials are presented to them.

At the end of the questionnaire several NP added comments of their own. In addition to issues already listed in the questionnaire, several of them emphasized the nationwide lack of plant nematologists as one factor that weakens nematology in relation to plant pathology. Others underscored the heavy burden of duties related to research, teaching and extension, which the NP must carry out so as to fulfill periodical evaluations. The balance among these duties is often obtained by reducing to a minimum the time and energy dedicated to improving teaching, including NT.

As occurred in Brazil^[7], in Argentina, Chile and Paraguay a significant proportion of agronomy schools apparently chose not to participate in this study. Most respondent schools are part of well structured, traditional teaching institutions. Hence, the worrying picture of NT that arises from this study may, in reality, be worse.

As for initiatives to improve NT, acting plant nematologists in Argentina and Chile could join forces to draw the attention of agronomy schools' administrators and course coordinators in all four countries to the negative impact of plant-parasitic nematodes on agri business and staple food crops, and the need to improve NT for future agronomists. Such a simple initiative was recently conducted by the Brazilian Nematological Society, giving support to a number of Brazilian NP to succeed in increasing the course-load of NT in relation to plant pathology, in creating elective nematology courses and in obtaining a nematology research facility. Locally, these achievements may start a virtuous cycle of more students involved with nematology research, more resources obtained from funding agencies and better addressing of nematology problems caused by plant-parasitic nematodes. Even if no national nematological societies exist in Argentina, Chile, Paraguay and Uruguay, as occurs in Brazil, plant protection or plant pathology societies could embrace this and other initiatives, as well as the International Federation of Nematology Societies.

In addition to initiatives to improve NT, as the problems presented by plant-parasitic nematodes become more common and complex, the demands presented to NP by the schools and students will likely drive improvements in NT and an increase in the course-load dedicated to nematology, as is currently happening in Brazil.

CONCLUSION

Nematology teaching is unsatisfactory in most agronomy schools in Argentina, Chile, Paraguay and Uruguay, with several factors collaborating to produce this situation.

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