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Compilation of Research Works that Contributed to the Development of Algerian Agricultural Nematology: A Review

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ABSTRACT

Investigation on plant-parasitic nematodes (PPN) in Algeria date back to the late 19th century. Important research has been performed since this period until currently generating significant information. The aim of this literature assembling is making available an outline of the current situation of plant nematology in the country. This review is based on the available information existing at universities' libraries and research articles obtained by visiting web pages and Google Scholar. All pertinent information was collected from 2018 until today. This review article shows three periods for Algerian agricultural nematology: First period includes the years of French colonialism and two decades after independence. Publications on PPN started in the late 19th and early 20th centuries by French and Italian researchers, working in Algeria. The second period (1980-end 1990s) was characterized by the emergence of Algerian researchers. They successively became central academics having the responsibility to educate graduate students. Their research topics were studies on geographical distribution and evaluation of damage degrees of some PPN. The third period (2000 until today) is characterized by the progression in nematological research in the country; research topics expanded and became more diverse. Collaboration between universities, National Institute of Agronomic Research and National Institute of Plant Protection are the organisations contributing to the development of nematology. Till date, a total of 38 genera and 43 species of PPN including economically important nematodes were documented in Algeria.

Key words: Agricultural nematology, Plant parasitic nematodes, Research institutes, Universities.

Nematology is the scientific discipline dedicated to study nematodes and the practical application of this knowledge (Prot, 1984).

Nematodes are a group of lesser-known but the most abundant group of multicellular organisms on earth. Nematodes belong to the kingdom Animalia. They can be defined as a group of thread/wormlike, transparent, bilaterally symmetrical in appearance but quite distinct taxonomically from the true worms. Most of species of nematodes live freely in fresh or salt waters or in the soil and feed on microorganisms, plants and animals. Numerous species of nematodes attack and parasitize humans and animals (Shah and Mahamood, 2017).

The emergence of Agricultural helminthology and Plant Virology as fresh disciplines has contributed to the recent evolution of agronomy and biological sciences (Manolache and Romascu, 1973). Agricultural helminthology studies particularly plant parasitic nematodes, this scientific discipline is included in soil biology and in phytopathology with other disciplines such as Mycology, Virology and Bacteriology (Prot, 1984).

Nematodes are associated with nearly every important agricultural crops. Symptoms caused by these pests are complex, damage on roots often decrease the capacity of plants to take up water and nutrients from soil and thus cause symptoms of water and nutrient deficiencies in the aboveground parts of plants. Infected crops will be affected on production and yields (Holgado and Magnusson, 2012; El-Sagheer, 2019; Kumar and Yadav, 2020). PPN rank among the most important threats to agricultural production, particularly in developing countries. Therefore, the promotion of this discipline is of great importance to ensure food safety in these countries.

In Algeria, investigation on PPN dates back to the late 19th, until today. Essential research has been conducted from this period until currently generating significant information; nevertheless, the information generated is dispersed with restricted access for students and researchers.

To the best of our knowledge, until now, no effort has been made to sum up the Algerian development of this discipline. The idea of writing this article occurred during the workshop on Plant Nematology in Algeria «1st workshop on nematology: Elements of diagnosis and management of

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some nematodes of economic importance for Algeria» in 23 to 29 of October 2018 by Djilali Bounaama University in Khemis Miliana (Algeria) in collaboration with Norwegian Institute of Bioeconomy Research (Norway).

The objectives of this review are to summarize and highlight the leading accounts from late 19th to today and provide a tool for universities and research institutes, provide with an overview of the current situation of plant nematology, point the main periods of its development, be aware of the leading researchers and organisms contributing to this development, identify the main knowledge gaps and make recommandations for future nematological research. The authors have made an effort for reaching all information feasible. However we would like to express our sincere apologies if any relevant facts or researchers have been omitted.

Methods

For the review different sources linking to research work on PPN were accessed. Official papers from national institutions were consulted: the Library of the Higher National Agricultural School of El-Harrach (Algiers) and library catalogues from Algerian universities. Theses and articles published obtained by visiting web pages accessible online and Google Scholar were categorized, reviewed and analyzed. In addition, important information was obtained through personal communications with Algerian scientists.

To collect information of web pages and Google scholar, search terms were prepared, the following terms were used: “nematodes in Algeria”. Common and scientific names of plant parasitic nematodes, genera and species adding “in Algeria”*e.g.* “*Meloidogyne* in Algeria”, “Root knot nematodes in Algeria, “*Xiphinema* in Algeria”, “*Pratylenchus* in Algeria”*etc*. further words were added before the name of plant parasitic nematodes: *e.g.* “occurrence”, “distribution”, “identification” *etc*. Additional family name of known Algerian nematologists were used as search terms *e.g.* “Sellami”, “Mokabli”, “Hammache” *etc*. Correspondingly for foreign nematologists recognized by their research in the country were also used as search terms *e.g.* “Dalmasso” “Lamberti”, “Scotto Lamassèse”.

All pertinent information was collected from 2018 until today (the mid-2023).

Development periods of nematology in Algeria

The literature analysis showed three main periods for the development of agricultural nematology in the country.

1st period: Include the period of colonialism and the earliest two decades after independence (until late 1970)

The initiation of Algerian Agricultural nematology, date back to late 19th and early 20th; where first reports on PPN in the country were pointed out by French and Italian researchers.

French/Italian researchers leading this first period

French researchers

Ferdinand Debray and Emile Maupas in 1896 studied *Tylenchus devastatrix*, today known as the stem nematode *Ditylenchus dipsaci*. They wrote in 1896 a book “Le *Tylenchus devastatrix* Kühn, et la Maladie Vermiculaire des Fèves en Algérie” printed by Orientale Pierre Fontana et Cie., today considered a classic book, the research conducted by Debray and Maupas was advanced and informative for this time library (Debray and Maupas, 1896). Debray was professor of botany in the Higher School of Algiers and Maupas was a curator of the National Library.

Louis Charles Trabut reported in 1915 *Tylenchulus semipenetrans* in citrus orchards (Trabut, 1915). Trabut was botanist and Professor at Medicine school of Algiers.

According to Scotto La Massèse (1962) the root-knot nematodes (RKN) *Meloidogyne* spp. was reported by Marcel Delassus in 1928, from horticultural areas of Mitidja. *Meloidogyne* was called at that time *Heterodera marioni*. Delassus was Chief of the Plant Protection Service in the country.

Pierre Frézal in 1953 reported, for the first-time potato cyst nematodes (PCN) *Globodera rostochiensis,* named at that time *Heterodera rostochiensis*. Frézal was the Head of the Department of Plant Protection; He was in charge of the crop protection courses at the Higher National School of Agriculture of Algiers/Ecole Nationale Agronomique d’Alger (ENAA) (Frézal, 1954).

Claude Scotto La Massèse, French/Algerian born in 1926, worked in the country until 23 December 1962. He worked as an engineer in the Plant Protection Department from 1950 to 1954, Graduate as Master of Research at INRA in 1961. During 1958 to 1962, he was the Administrator of the Agricultural Research Center of Algeria. His research increased the knowledge of PCN, including geographical distribution; aspects contributing to their dissemination (Scotto La Massèse, 1961). In 1962 he reported the occurrence of cereal cyst nematodes (CCN) *Heterodera avenae* (Scotto La Massèse, 1962).

Claude Scotto La Massèse was relocated to live in France (end of 1962), but he carried on with his research work in Algeria, particularly studying *Tylenchulus semipenetrans* nematodes associated with Citrus (Scotto La Massèse *et al*., 1973; 1975).

Didier Mugniéry from National Institute of Agronomic Research (INRA) of France and Helène Zaouchi from the Center of Agronomic Research of Algeria, studied PCN control and management (Mugniéry and Zaouchi, 1973). Further Helène Zaouchi investigated methods for management of *Tylenchulus semipenetrans* (Scotto La Massèse *et al*., 1975). Zaouchi studied the damage caused by PPN on date palm and olive in collaboration with Italian nematologists (Lamberti *et al*., 1975).

Antoine Dalmasso and Michel Luc studied Longidorid nematodes during 1960s (Dalmasso, 1969; Dalmasso and Cuany, 1969).

Italian nematologists

Franco Lamberti and Nicolas Greco studied PPN associated to major crops such as date palm, olive, horticultural crops, cereals and legumes (Lamberti, 1973; Lamberti *et al*., 1975).

2nd period: (1980-end 1990)

Studies on the longidorid nematodes were conducted by Michel Luc (French), Atanas Kostadinov (Bulgarian), Franco Lamberti and Alberto Troccoli (Italian) (Luc and Kostadinov, 1981; Kostadinov, 1985; Troccoli *et al*., 1992; Lamberti *et al*., 1992).

In our opinion the establishment of agricultural nematology research in Algeria occurred in the course of the 2nd period, with the following scientists: Ouanouki Farida and Sellami Samira, first ladies interested in nematology, international collaboration starts to yield Algerian nematologists *e.g*. Mokabli Aissa was trained and supervised by Professor Mohamed Mouldi B'chir from Tunisia working at the Institut National Agronomique de Tunisie INAT and Roger Rivoal from France (INRA, Centre de Recherches de Rennes).

The training in Algeria on nematological subjects started with Sellami Samira; she supervised and trained Hammache Miloud. In this period, Sellami, Mokabli and Hammache were the main nematologists in the country, they continued with training in nematology, supervising theses for degrees of Engineering, Magister and PhD. Today most of their students are ensuring the continuity of nematology and are working in the National Institute of Plant Protection and others are lecturers in several Algerian universities.

At the library of the Higher National Agronomic School ENSA (previous INA) the research work related to PPN are registered: 62 Engineering dissertations and 8 Magister thesis. The topics of these eight theses were RKN (3), *Heterodera avenae* (3), *Tylenchulus semipenetrans* (1) and *Ditylenchus dipsaci* (1).

Three papers were published in this period by Algerian researchers; two in Annales de l'Institut National Agronomique: (Mokabli, 1988; Ouanouki and Ighili, 1988) and one published in Nematologia Mediterranea (Sellami *et al*., 1999).

3rd period (2000 until mid-2023)

This period is characterized by the progression in nematological research in the country and expansion on research topics as nematode biology; nematode communities; molecular identification and methods for management (Chemical, biological and cultural control).

Our review found that in Algiers at the ENSA are registered 17 magister and 16 PhD thesis. The topics for magister degree were RKN (8), CCN (5), PCN (3) and *Ditylenchus dipsaci* (1).

The topics for PhD thesis were CCN (Mokabli, 2002; Haddadi, 2015; Djetti, 2019; Rahim, 2021 and Mehalaine, 2021), PCN (Tirchi, 2015; Mezerket, 2018; Djebroune, 2019; Benttoumi, 2022), RKN (Hammache, 2012; Babaali, 2017; a part of the thesis of Morsli, 2018; Zaidat, 2021). Nematodes associated with olive (Lounici-Belahmer, 2018); nematodes associated with vine (Hoceini, 2015), nematode communities in natural area (Berrabah, 2017), Additional, at the ENSA 46 engineering dissertations and 25 master theses related to PPN are archived.

In Algerian universities theses dealing with PPN were recorded: A total of 5 magister and 4 PhD thesis.

The topics of these PhD thesis were: Nematode communities associated with vegetable crops: NebihHadj-Sadok (2013), University of Blida.

CCN: Labdelli (2015), University of Tiaret; Righi (2016), University of Mascara.

Ditylenchus dipsaci: Saadi (2019), University of Biskra.

Papers were published in national and in international journals. We could catalogue 54 publications on the following topics.

Root-knot nematodes

National journals

Djerroudi-Zidane *et al.* (2011) Revue des BioRessources; Nebih Hadj-Sadok *et al.* (2014) Agrobiologia.

International journals

Sellami and Zemmouri (2001) and Sellami *et al.* (2017) Acta Phytopathologica et Entomologica Hungarcia; Sellami *et al.* (2010) Nematologia Mediterranea; Hammache (2010) Lebanese Science Journal; Aoudia *et al.* (2012) Journal of Agricultural and Food Chemistry; Babaali *et al.* (2016) Advances in Environmental Biology; Djerroudi-Zidane and Sellami (2017) International Journal of Sciences and Research; Babaali *et al.* (2017) Journal of Plant Diseases and Protection; Benttoumi *et al.* (2020b) Plants (deals also with PCN); Zaidat *et al.* (2020) Egyptian Journal of Biological Pest Control; Babaali *et al.* (2021) Nematology; Sabri *et al.* (2022) Archives of Phytopathology and Plant Protection.

Potato cyst nematodes

National journals

Nebih Hadj-Sadok and Charif (2019) Agrobiologia.

International journals

Tirchi *et al.* (2015) International Journal of Agricultural Science and Research; Tirchi *et al.* (2016) European Journal of Plant Pathology (deals also with CCN); Tirchi *et al.* (2017) Academic Journal of Biological Sciences; Mezerket *et al.* (2018) Journal of Agricultural Science and Technology; Benttoumi *et al.* (2020a) Bioscience Research; Djebroune *et al.* (2020) Pakistan Journal of Zoology; Djebroune *et al.* (2021) Pathogens; Berrahia and Sellami (2022) Journal of Agricultural Science and Technology.

Cereal cyst nematodes

International journals

Mokabli *et al.* (2001a) Nematologia Mediterranea; Mokabli *et al.* (2001b) and Mokabli *et al*. (2002) Nematology; Haddadi *et al.* (2013) Phytoparasitica; Smaha *et al.* (2014) International Journal of Zoology; Labdelli *et al.* (2014) International Journal of Bio-Technology and Research; Righi *et al.* (2015) Journal of Chemical and Pharmaceutical Research; Righi *et al.* (2016) Journal of Applied Environmental

and Biological Sciences; Labdelli *et al.* (2017) Journal of Fundamental and Applied Sciences; Smaha and Mokabli (2017) Advances in Environmental Biology; Smaha *et al.* (2018a) and Smaha *et al.* (2018b) Plant disease; Djetti *et al.* (2018) Arxius de Miscel·lània Zoològica; Smaha *et al.* (2019) Journal of Plant Protection Research; Righi *et al.* (2019) Cahier Agriculture; Smaha *et al.* (2020) Revue Marocaine des Sciences Agronomiques et Vétérinaires; Rahim *et al.* (2020) Plant Archives; Mehalaine *et al.* (2021) Nematropica; Mekhaneg *et al.* (2022) Plant Archives (deals also with PCN).

Nematodes associated with vegetable crops

International journals

NebihHadj-Sadok *et al.* (2011) Nematologia Mediterranea; Berrabah *et al.* (2014) Revue des Régions Arides; Bissaad and Bounaceur (2016) Scientific Papers. Series A. Agronomy.

Nematodes associated with olive

National journals

Hoceini *et al.* (2016) Revue Ecologie-Environnement.

International journals

Chafaa *et al.* (2014) Journal of Animal and Plant Sciences; Belahmar *et al.* (2015) Acta phytopathologica et Entomologica Hungarcia.

Stem and bulb nematode

National journals

Saadi and Benbouza (2018) Courrier du Savoir.

International journals

Saadi *et al.* (2019) European Journal of Plant Pathology.

Nematodes associated with vine

International journals

Bounaceur *et al.* (2011) Annals of Biological Research; Hoceini *et al.* (2017) Advances in Environmental Biology; Smaha *et al.* (2023) Nematropica.

Nematode associated with medicinal plants

International journals

Berrabah *et al.* (2016) Advances in Environmental Biology.

Main plant parasitic nematodes reported in Algeria

The reviewed documents, from the late of 19th century until today, give an account of 38 genera and 43 species of PPN.

The stem and bulb nematode *Ditylenchus dipsaci* reported in 1896 constitute a limiting factor for production of legume crops and especially beans (Sellami and Bousnina, 1996; Troccoli and Di Vito, 2002). *Ditylenchus gigas* which is considered a giant race of *D. dipsaci* sensu strict was detected in bean fields (Saadi and Benbouza, 2018; Saadi, 2019; Saadi *et al.*, 2019).

Saadi *et al.* (2019) reported for the first time the presence of *Ditylenchus oncogenus* on *Vicia faba* in Algeria.

The Citrus nematode *Tylenchulus semipenetrans* was reported in 1915. Surveys conducted in 1975, showed that *T. semipenetrans* is widely distributed on the main citrus plantation areas (Scotto La Massèse *et al.*, 1975).

The RKN *Meloidogyne* spp. has been reported by Delassus in 1928 in the horticultural areas of Mitidja. Recently *Meloidogyne* has been detected in almost all vegetable areas, they are also found in Oasis crop systems (Mokabli, 1988; Ouanouki and Ighili, 1988; Sellami *et al.*, 1999; Hammache, 2010; Nebih Hadj-Sadok, 2013; Babaali, 2017; Benttoumi *et al.*, 2020b). Hammache (2010) signalled the occurrence of *Meloidogyne incognita*, *M. javanica* and *M. arenaria* in green houses (Hammache, 2010).

Concerning PCN, they were recorded for the first time by Frézal in 1953; in El-Harrach named at the time «Maison-Carrée» (Algiers) (Frézal, 1954). A year after, they were recorded along the Algerian coastal where potato was produced (Scotto la Massèse, 1962). Our revision didn't find papers on PCN for the period 1962 until late 1980s. The first Engineering works was carried on mid 1990s at the INA. Surveys conducted from 1990s until today confirmed the distribution of PCN in most of potato producing regions (Masters and Engineering non published works; Tirchi, 2015; Mezerket, 2018; Djebroune, 2019; Benttoumi *et al.*, 2020; Berrahia and Sellami, 2022). Both species *Globodera pallida* and *G. rostochiensis* occur in Algeria (Tirchi *et al.*, 2016; Mezerket *et al.*, 2018; Djebroune *et al.*, 2021).

The CCN *Heterodera avenae* is reported in 1962 and 1975 (Scotto La Massèse, 1962 and Lamberti *et al.*, 1975). Surveys have revealed that *H. avenae* species is common occurring in the main cereal-producing regions but other CCN were recorded *H. latipons*, *H. mani*, *H. filipjevi* and *H. hordecalis* (Mokabli, 2002; Haddadi, 2015; Labdelli, 2015; Tirchi *et al.*, 2016; Righi Assia *et al.*, 2019; Smaha *et al.*, 2018a; Smaha *et al.*, 2018b; Smaha *et al.*, 2019, Rahim *et al.*, 2020; Mehalaine *et al.*, 2020). *Heterodera carotae* and *Heterodera cruciferae* were reported by Mehalaine *et al.* (2020) for the first time in Algeria.

Surveys undertaken by Di Vito *et al.* (1994) in North African countries including Algeria revealed the presence of several nematode species associated with chickpea, faba bean, lentil and pea. Root-lesion nematodes were the most widespread nematodes on all crops.

In the country, *Pratylenchus penetrans* was the common species damaging legume crops. *Pratylenchus thornei*, *P. neglectus*, *P. crenatus*, *P. mediterraneus*, *Pratylenchoides leiocauda*. *Zygotylenchus guevarai* and *Meloidogyne artiellia* were also reported.

The pea cyst nematode *Heterodera goettingiana* was reported by Lamberti and Dandria (1979) cited by Di Vito and Greco (1986) and Di Vito *et al.* (1994).

The lesion nematodes *Pratylenchus penetrans* occurred in Algerian oasis and is causing the decline complex of the date palm (Lamberti, 1973). Studies conducted

by Lamberti *et al.* (1975) shown that *P. penetrans*, dagger nematode *Xiphinema elongatum* and needle nematode *Longidorus congoensis* were the most damaging nematodes for date palm in the country. They also reported *Helicotylenchus*, *Pratylenchus*, *Rotylenchulus* and *Tylenchorhynchus* in olive orchards. Troccoli *et al.* (1992) reported *P. penetrans* associated with date palm and *P. thornei*, *P. pratensis*, *P. scribneri* and *P. neglectus* were found in rhizosphere of cereals and vegetables crops.

During surveys conducted in vineyards from different regions of Algeria, several longidorid nematodes were recorded: *Xiphinema*, *Longidorus* and *Paralongidorus* (Dalmasso, 1969; Dalmasso and Cuany, 1969). *Xiphinema sahelense* and *Paralongidorus epimikis* have been described as new species by Dalmasso (1969). Dalmasso recorded also *Paralongidorus maximus* in 1969. During studies by Luc and Kostadinov (1981) in vineyards at the region of Mostaganem, *Xiphinema algeriense* has been described as a new species. Lamberti *et al.* (1992) described *Xiphinema adenohystherum* from Algeria as a new species. Other *Xiphinema* species were reported in Algerian vignards: *X. italiae*, *X.* index, *X. pachtaicurn, X. sahelense*, *X. turcicum, X. americanum* and *X. revesi* (Luc and Dalmasso, 1975; Luc and Kostadinov, 1981; Kostadinov, 1985; Smaha *et al*., 2023).

Further studies conducted on vegetable crops, vineyards, olives and in natural area reported the occurrence of: *Helicotylenchus pseudorobustus* and *Hemicycliophora* (Ouanouki and Ighili, 1988), *Aglenchus*, *Amplimerlinus*, *Anguina*, *Aphelenchus, Aphelenchoides*, *Boleodorus*, *Criconema*, *Criconemoides*, *Hemicriconemoides*, *Coslenchus*, *Gracilacus*, *Globodera*, *Ditylenchus*, *Hoplolaimus*, *Helicotylenchus*, *Longidorus*, *Meloidogyne*, *Nothotylenchus*, *Paratrichodorus*, *Paratylenchus*, *Paratylenchoides*, *Pratylenchus*, *Psilencus*, *Rotylenchulus*, *Scutellonema*, *Tylenchorhynchus*, *Rotylenchus*, *Rotylenchulus*, *Tylenchus*, *Tylenchulus*, *Trichodorus*, *Telotylenchus*, *Trophorus* and *Xiphinema* (Bounaceur *et al*., 2011; Nebih-Hadj-Sadok, 2013; Hoceini *et al*., 2014; Chafaa *et al*., 2014; Berrabah *et al*., 2014; Hoceini, 2015; Belahmar *et al*., 2015; Bissaad and Bounaceur, 2016; Berrabah, 2017; Hoceini *et al*., 2017) and *Bursaphelenchus* which was detected for the first time in Algeria by Berrabah (2017).

Seeing back publications from the late 19th century until today, we appreciate that important research has been carried out on PPN and give a background for further research. PPN of economic importance have been recorded in Algeria. These nematodes are frequently a limiting factor on a wide range of crops commonly grown in the country, including economically important crops such as cereals, potato, date palm, olive *etc.*

International cooperation

The cooperation between Algerian researchers and European research institutes started during 1980-1990 and increased in 2000.

Teachers and researchers from Algerian universities are visiting European research institutes to learn nematological research techniques. Also, PhD students are visiting research institutes in order to support their PhD work. Algerian government is providing with grants for travels and accommodation, institutes from Italy, France, Spain, Germany, Portugal and Norway, have been open-handedness by receiving Algerians, in their laboratories without charge, training them and helping them to write papers. The visited institutes are: Institut National de la Recherche Agronomique (INRA) in France, Consiglio Nazionale delle Ricerche (CNR) Bari, Italy, Institute of Research and Development (IRD), Montpellier, France, Norwegian Institute of Bioeconomy Research, Division of Biotechnology and Plant Health , Institute for Sustainable Agriculture, CSIC, Instituto de Agricultura Sostenible (IAS), Córdoba Spain, Carolina Cantalapiedra-Navarrete, Julius Kühn-Institut, Federal Research Centre of Cultivated Plants, Institute of Epidemiology and Pathogen Diagnostics, Germany and Instituto Nacional de Investigação Agrária e Veterinária, (INIAV). Oeiras-Portugal. Instituto de Investigación y Formación Agraria y Pesquera, IFAPA, Almeria, Spain, Bolu Abant Izzet Baysal University, Golkoy, Bolu, Turkey.

The international collaboration between Algerian universities and European institutes has been very productive; this could be perceived on publications where authors are Algerian and European. This collaboration could also be perceived as conferences, seminars and workshops organized in Algeria. During these events, European researchers have shared their experience with Algerian and contribute in training researchers, students and farmers. In addition, International collaboration has, assist Algerian researchers for their participation in conference and seminars organized in European countries.

However, this scientific collaboration is always temporary and implicates a good part of individual initiatives that brings only punctual collaboration. Therefore, there is a need for establishing a more formal and stable collaboration, through signed official conventions between the Algerian universities and research institutes of other countries.

Principal Algerian institutes contributing to nematology development

The nematological research in the country is conducted by universities, INRA (National Institute of Agronomic Research) and INPV (National Institute of Plant Protection). These institutes contribute also to the capacity building of farmers, advice them on PPN and help them to solve agricultural problems caused by these pests.

Universities are keen to teach and, prepare graduate students, who may later become specialists. INPV is in charge for management of quarantine and non-quarantine nematodes. It participates actively in advisory program for

educating farmers. INPV and INRA host and mentor students to carry on their research work. These institutes participate in workshops, study days and seminaries on PPN organized by the universities around the country.

Place of nematology in Algerian universities

In the academic programs for agronomic sciences, Nematology is included in the programs placed on the "classical system"(engineering graduate teaching, magister and PhD in post studies) or in the new system LMD (License-Master- Doctorate).

In classical system: the second year of engineering, students have in the module of Zoology a section dedicated to nematodes and in the course of the fourth year students of the specialty Plant Protection- phytopathology, have a module entitled "Illnesses due to nematodes". In LMD system: the program of the license of "Plant protection" contains a module entitled "The main animal bio-aggressors" that includes a chapter dedicated to nematode and for the licence of "Plant production" students have a module called "harmful nematodes".

In our opinion, in Algerian universities the time used in nematology is insufficient; the courses offered are only an initiation in general nematology. There is a need to establish an appropriate nematology specialty. We noted also several limitations that obstruct the progress of this discipline, particularly the limited financial resources, shortage in scientific equipment in nematology. Therefore, further consideration needs to be given to the development of this discipline in Algerian universities.

CONCLUSION AND PERSPECTIVES

Algerian agricultural nematology is characterized by three periods. The information collected concerning those periods indicates that, from the end of 19th century until today, reported 38 genera and 43 species of PPN, including nematodes of economic importance.

Research topics studied were morphological and molecular identification, geographical distribution, population densities, nematode communities and methodologies to management. However, there is a knowledge gap concerning the biology of main groups of nematodes under Algerian conditions; little is known about the effects of pathotypes, nematode virulence, plant resistance and economic impact produced.

Universities, National Institute of Plant Protection and the National Institute of Agronomical researchers have been contributing to nematological research. However, it is essential that the established collaboration expands. There is a need for increasing the international collaboration between Algerian universities and European research institutes by official conventions.

In Algerian universities effective teaching is critical for the development of nematology. In order to achieve this, the administration in charge of high education must provide the necessary input to improve nematological education.

There is also a need to create a group of Algerian working in plant nematology from universities and research Institutes including the National Institute of Agronomical Research and the National Institute of Plant protection. Periodical meeting of Algerian researchers, students working in nematological issues, possibly will encourage investigation on nematology subjects in Algeria; these gatherings could serve as a platform for resenting fresh outcomes, share experiences and for highlight topics of research.

Finally, it is important that the aspects on future research reflected all aspects of agricultural nematology in a more extended context that is plant protection and preservation of agrosystems.

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Conflict of interest

All authors declare that they have no conflict of interest.

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