SAVING THE ENVIRONMENT THROUGH NEMATOLOGICAL INNOVATIONS AND TECHNOLOGY DEVELOPMENT

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ABSTRACT

Pests-host interactions and the need for food and human health security constantly places the environment under pressure. Challenge of climate change, which is a global phenomenon further influences the pest-host interactions with resultant surge of new pests and mounting pressure on the environment. Nematodes are known as the most numerous organisms in the universe and managing them requires integrated innovation that would ensure stability of the ecosystem while effectively controlling their menace. Hence nematologists need to be pro-active to package research results for national development while encouraging research continuity and product development. Cottage industries could result from research findings thereby empowering the citizenry. This would have ripple effect of promoting capacity building, especially of nematologists, and development of nematology curriculum in higher institutions of learning. The environment would be salvaged from the mounting pest pressure when through multidisciplinary nematology research we establish linkages, networks and collaborative research that would ensure that environmentally friendly options of nematode management are given priority position. Nematode challenges are public health issues and success in nematology research could lead to health improvement. Applications of nematodes as model organisms in cytology and cyotoxicology studies to unravel major health challenges as it had been done with *Ceanorhabditis elegans* is novel. To be able to come up with innovations that could save our environment we should advocate persistence and resilience in research, define our research focus and targets.

INTRODUCTION

“If crop pests continue to spread at current rates, many of the world’s biggest crop producing nations will be inundated by the middle of the Century, posing a grave threat to global food security”(Bebber, in BBSR Business, 2014). This is a reflection that the environment is under pressure and we must beware how we handle it.

As pathogen and pest pressure mounts, global food security is threatened! Hence we wonder, “Is there going to be famine”? The essence of this paper is not to blow an alarm or present a problem out of proportion; rather, it is a call for us to salvage the environment. Nematodes are important groups of animals that may either contribute to the mounting pressure or be useful in deflating it through nematological novelty and technological expansion. Gurr in BBSR Business (2014) submitted that if plant protection strategies and biosecurity measures are implemented, particularly in the developing world where knowledge is scant, there is hope. Whether such precautions can slow or stop this process remains to be seen.

Nematodes?

The technical definition of nematode has been given by Egunjobi (2014) in this current volume of NIJON. However, I present briefly, a general grouping of nematodes, which is pertinent to my presentation. Nematodes may be grouped as either parasitic or free-living; the parasitic being either plant or man and animal parasitic (Figure 1). Man and animal parasitic nematodes are important public health issues, causing disease and discomfort to man and his animals, while plant parasitic nematodes limit sustainability of food production and so threaten food security. The free-living nematodes are useful in nutrient cycling, environmental assessment and ecotoxicological studies. Knowing that there are diverse possibilities with nematology, we need to take research very serious and focus on development oriented research that would ensure environmental health and sustainability.

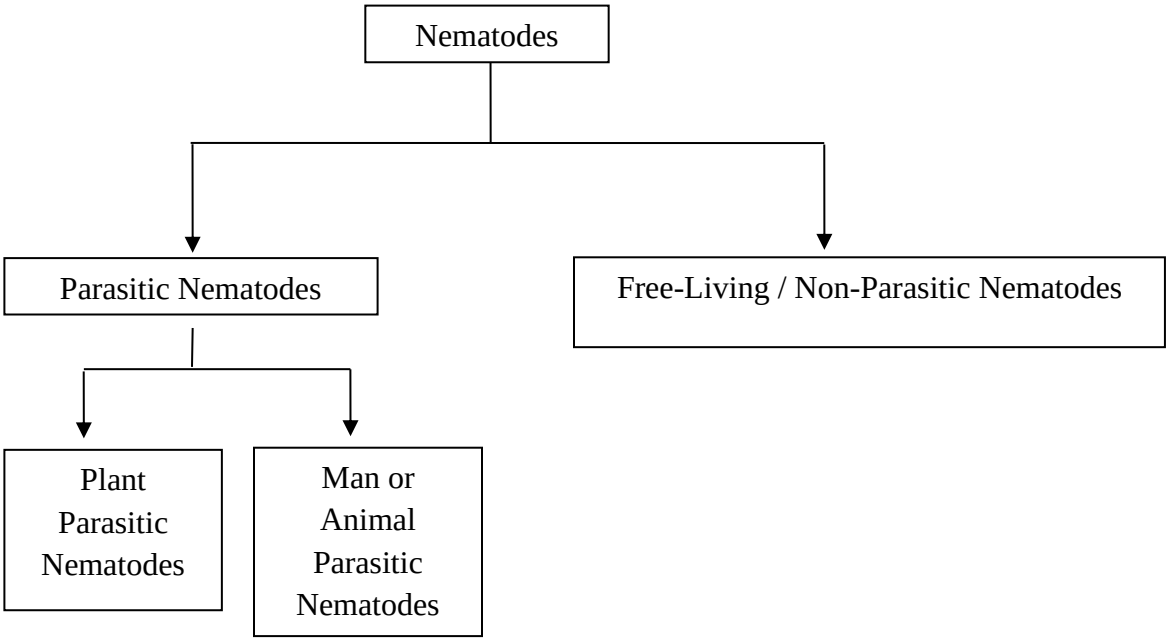

Figure 1. Grouping of nematodes

RESEARCH ORIENTATION AND NEMATOLOGICAL OUTLOOK

Focused and persistent research brings innovation. Have you ever asked how come the United States of America could have a solution to an African problem and were able to offer hope? The difference lies in their understanding of the significance of research. Not only is their government actively involved in research, multinationals like seed, pharmaceutical and chemical companies for instance all get involved with research, specifically funding, in partnership with academics. They are aware that research might mean up to 10 or 20 years funding of research and development of research facilities at a host institution. At the end of the day, what you have is a product which may be seed, chemical, procedure, etc for such company but in return, manpower development in the country, national development and research strength would be enhanced in institutions that are involved and facilities provided by the research grants. Although it may be easier and more convenient to seek fellowship outside for yourself for example or you are affiliated with an international organization, at the end of the day, you may remain dependent on such bodies offering you the services. We must strive to bring development by attracting research grants that would make provision for a wider scope of development. I must quickly point out that when we talk of the science of Nematology, we are looking at a broad sense; across science, agriculture and health disciplines; although often times, we equate nematology with crop protection or plant

pathology. There is tendency to do that especially in developing countries where it is often considered as an applied discipline. Whereas in developed nations, the Science of Nematology is taught as an all embracing science and you will understand how it has its origin in Zoology or Biology.

Free-living nematodes are important groups of animals, useful in several respects but are least studied. However, they are useful as entomopathogens, relevant in pollution studies and may help in soil classifications. For example certain free-living nematodes are known for their different habitats in different soil types, e.g. in sandy soil, in loamy soil, in clayey soil. You could also use soil type to project or determine what type of nematode community is expected to be a problem on a farm site or on crop types, etc. Nematode community structure after disturbing a soil would differ from the community structure of a soil structure that had been left undisturbed for a period of time. Hence, nematodes may be good indicators of soil disturbance.

Animal parasites are also important. I can imagine if there were to be a report of an outbreak of a disease whose pathogen is a nematode like we had the Ebola virus disease. A case where the nematode develop resting bodies like cysts, which could remain viable for a long period of time in an unconducive environment, where nematodes are carried in soils, water bodies, food produce/ perenating tissues including aerial plant parts, animal excreta, etc.; we would have had a big epidemy to contend with!

Environmental concerns in the control of plant parasitic nematodes, especially in intensively cultivated high value crops call for search for alternatives that are environmentally safe and sustainable. Occupational hazard in the use of nematicides, known for high mammalian toxicity, makes their use in Nigeria and other developing countries a serious challenge and concern. This has led to several Nigerian Nematologists exploring the efficacy of environmentally safe options like medicinal plant extracts, antagonistic plants, composts, organic mulches and other biological interventions in nematode management.

Extensive cultivation currently (embarked upon) employed in Nigeria by the Minister of Agriculture, Dr. Akinwumi Adesina is laudable but the challenges are huge. Nematode populations build up fast under a suscept (or susceptible plant/crop) and over time may reach an alarming proportion. Plant parasitic nematodes are considered the cause of soil sickness (Rotimi, 1996),

leaving the land with patchy crop growth. This could be a challenge in pastures and an issue in an area where lawns are to be maintained because there would be uneven growth; hence horticultural landscaping for aesthesis becomes more expensive because of the need for nematode control that would ensue.

Plant parasitic nematodes are hidden enemies of crops because of their "hidden nature": they do not live signs on the plant and sometimes, plants may be asymptomatic. Where there are symptoms they may appear similar to that of mineral nutrient or water deficiency, especially wilting symptoms. Hence, extension nematologists are highly vital while basic nematological works must be done in our laboratories all over the federation. If not informed about nematological challenges, a farmer may keep applying inorganic fertilizers in increasing rates. Consequently, soil acidity increases, soil biotic structure changes, pest status of some nematode species also changes. Similar to other pests and pathogens, on a field where nematicide had been used to control more serious nematode species like *R. similis*, *P. coffeae*, a species like *Hoplolaimus* would for example surge to become a major species (Rotimi and Speijer, 2004). Nematode community structure changes with environmental conditions; hence we must understudy environmental impact assessment with these organisms in microcosms and understand factors that influence their diversity.

FOOD SECURITY AND ENVIRONMENTAL PROTECTION

Hirshmaniella oryzea (rice nematode) and *Meloidogyne* spp. are serious pests of rice (Le *et al*., 2008), *Heterodera sacchari* is also a serious spp. on sugar cane (Salawu, 1994). In recent time food production is being promoted in Nigeria and large acres of land were open up and put to large scale intensive rice production. We must be on top of the situation. The question we should ask is "do we have trained technicians to do technical work, nematode identification, etc"? We must start thinking of how to build a technical workforce to get involved in diagnostic work, thereby creating jobs. New industries would also develop with further innovations.

NEW INDUSTRIES DEVELOPED

The use of inorganic fertilizer and other synthetic chemicals could result in increased soil acidity. Innovations of the use of organics (biofertilizers, compost, botanical extracts, etc) would reduce soil acidity and destruction of biotic life of the soil, improving plant health and enhancing nematode suppressiveness. Botanicals that show promise in nematode control may also serve dual purpose as liming agent. For example, investigators established the nematicidal efficacy of red *acalypha* leaf extract against *Pratylenchus coffeae, Radopholus similis, Helicotylenchus multicinctus* and *Meloidogyne* spp. complex on banana, plantain and tomato (Olaniyi, 2014; Rotimi *et al.*, 2005).

Recently, red acalypha was documented to show liming capability (Olaniyi, 2014a & b). This type of discoveries could be a good factor to consider in developing an integrated pest and soil management scheme. We may not successfully talk of nematode management without considering soil management.

Companies producing biocontrol agents in the search for the control of plant parasitic nematodes with environmentally friendly products have discovered and compounded organic fertilizers which are made of living microorganisms. Mycorrhizal fungi for instance have been packaged as biofertilizers and bionematicides. Olaniyi (2012, 2014) and Olaniyi and Osuloye (2014 a & b) enhanced the tolerance of cooking banana and plantains to plant parasitic nematode damage on the field and concluded that cultivar differences existed among plantain and banana cultivars in the benefit they derive from the application of mycorrhizal inoculant. Nematodes have also been utilized in the biological control of other pests like insects. Entomopathogenic nematodes are free-living and have received greater attention in recent times. Companies like e-nema at Kiel, Germany have emerged as products of nematological research due to the persistence of the Nematologist. With focus and persistence, several innovations are possible and several jobs can be created. What became e-nema today came about from the results of the PhD work of Prof. Ralf Ehlers on entomopathogenic nematodes and he is constantly doing research to improve on the company's products and the company takes in and funds PhD student research. This is how partnership develops. Hence, innovation in nematological research would lead to capacity building, development and even enhanced environmental health. Possibilities in nematology are high, the science should be popularized.

Biocontrol is also practiced with man/animal parasitic nematodes (helminthes); hookworms & whipworms of man and dog respectively fall into this category and biocontrol tries autoimmune diseases and immune disorders using helminthic therapy by means of deliberate infestation with a helminth or the ova (Otubanjo, 2013).

BIOLOGICALLY SAFE ENVIRONMENTAL ASSESSMENT AND BIOTHERAPY

The application of nematodes in pollution and ecotoxicological studies has been extensively studied at developed institutions like the University of Ghent, Belgium and Department of Animal Ecology at the Bielefeld University in Germany. Other applications include biomonitoring of lakes and streams, the use of *C. elegans* (a free-living nematode) in biotests to assess soils and sediments. Free-living nematodes that are implicated in decomposting of soil, plant and animal matter can also be used in the assessment of soil fertility status. All these applications would open up new jobs and industries.

The quest for environmental friendly options in nematode control led me to develop a therapeutic procedure for herbal management of breast cancer complementarily to chemotherapy. This therapy has been successfully administered by four independent subjects (women with breast cancer cases) but not strictly as a clinical trial. In the most striking of the subjects, a histological diagnosis of breast cancer was established, with a mass measuring 80 x 50 mm and an overlying ulcer measuring 50 x 40 mm. The Oncologist's conclusion of this case was a malignant breast cancer of BIRADS category 5. In less than four weeks of strict adherence to the herbal therapeutic guideline, which consisted largely of water, fruits, vegetables, and extracts of mistletoe (*Viscum album)* leaves and sour sop or graviola (*Annona muricata*) leaves and bark, the tumour had shrunk to 27 x 20 mm. Four weeks into the commencement of the therapy, she started chemotherapy but continued with the consumption of the herbal extracts, underwent a couple of surgeries and took a complete dose of chemotherapy spread over time. Seven months after the commencement of this therapy and with conclusion of chemotherapy, histology reveled that there were no more active cancerous cells in the breast. She concluded treatment with radiotherapy and did a whole body bone scintigraphy and received a report of no noticeable cancerous tissue. A few others have also tried it out not because they believe natural herbs are useful but because when a threatening

diagnosis is given, it is human to want to try "anything" that is said to be helpful. Varying levels of success have been recorded but there had not been any concerted clinical trials with subjects.

There is need to harness available information and present in a manner that would attract collaborations in multidisciplinary fields of study. An herb that would effectively control *Meloidogyne* spp and prevent gall formation on the plant for instance, may be explored for its anti-tumor or anti-cancer properties in man. This would ensure collective national development, health and capacity building.

Environmental pollution management is also possible with nematology: free-living nematodes that digest petrochemicals and use as energy source can be explored. These free-living nematodes can also be used as biological detector and assessors of pollution in ecotoxicological studies in soil and water (including fresh, ocean or brackish water). Soil fertility status may even be determined by assessing the diversity of free-living nematodes in the soil.

PUBLIC HEALTH ISSUES

Intestinal round worm, *Ascaris lumbricoides* Linnaeus, 1758, the commonest, largest and most widespread nematode parasite of man causes ascariasis, which is an important public health problem (Otunanjo, 2013). However, it is easily spread through infested soil. Hence, care should be taken on organic control of plant parasitic nematodes using human feacal sludge because of likelihood of habouring *Ascaris lumbricoides* eggs or eggs of other parasitic nematodes. Human (or pig) feaces used as fertilizers should be fermented at 50^{o}C or higher, to kill the eggs; always take precaution.

NEMATODES AS MODEL ANIMALS

Nematodes are model animals in developmental Biology. *Ceanorhabditis elegans*, a free-living nematode is a veritable tool in this regard.

Caenorhabditis elegans: A Model Animal

Taxonomic classification

Kingdom: Animalia

Phylum: Nematoda

Class: Chromadorea

Order: Rhabditida
Family: Rhabditidae
Genus: *Caenorhabditis*
Species: *elegans*

Caenorhabditis elegans has revolutionized the way we approach genetic studies to understand how genes regulate cellular activities, study embyonic development, neuronal functions, lifespan and aging, and molecular basis of some human diseases.
The *C. elegans* has simple genetics, transparent body and is easy to cultivate

Applications

- *C. elegans* can be used to answer many important scientific questions.
- Highly convenient model system for studying neurobiology
- Also an ideal choice for aging studies. The worm's short life span has allowed researchers to conduct genetic screens for finding longevity genes. Although many of these genes are conserved in humans, we do not yet know whether or not they affect lifespan in people.
- Worm research has also advanced our knowledge of human diseases.
- Genetic screens in worms have helped to identify genes that prevent the loss of neurons in neurodegenerative diseases, such as Parkinson's and Alzheimer's disease.

Awards resulting from nematology research

- 2002 Nobel Prize in Physiology or Medicine was awarded Sydney Brenner, H. Robert Horvitz and John Sulston for their work on the genetics of organ development and programmed cell death in *Caenorhabditis elegans*.
- 2006 Nobel Prize in Physiology or Medicine was awarded Andrew Fire and Craig C. Mello for their discovery of RNA interference in *C. elegans*
- In 2008, Martin Chalfie shared a Nobel Prize in Chemistry for his work on green fluorescent protein; some of the research involved the use of *C. elegans*

An overview of the model organism Caenorhabditis elegans

This tiny worm, *Caenorhabditis elegans*, with its simple genetics and diminutive nervous system, has helped us to understand numerous aspects of human development, behaviour, aging and disease (http://www.jove.com/science-education/).

Collaboration is important in encouraging innovations and using research to meet needs. A good strategy would be to form research groups and complement one another, develop lasting research policies that would ensure direction is given research work in our tertiary institutions and research institutes (Olaniyi, 2010). It is actually not that many colleagues from developed countries are better than us in research skill; the difference is that they learnt documentation and organization early in their professional careers. Hence, our Society, Nigerian Society of Nematologists, should endeavour to help us chart a meaningful course and strengthen our cohesion. Persistence is a major issue that challenges innovation; we must follow through with research and not always be in a hurry for results or paper publication, although our national system may demand such. Otherwise, the relevance of our research to national development is weakened irrelevant. It is when we focus or on developmet oriented research that we would become better attractive to collaborating international organizations. We should be innovative in what we do in order to bring about the desired change.

CONCLUDING NOTE

Research focus is an important issue that would encourage innovation. However, this may be a challenge because good research is not cheap and in a bid to source for funds for research, you may need to prepare your proposal to suit the interest of the funding organization, which may be divergent from your focus. Otherwise, chances of getting your research funded may be slim. Although it is good to have a broad experience it is more rewarding to be distinctly focused. In this way, you become relevant to development over time because you would have persisted in the area where you are comfortable and make meaningful impact. We should bring professionalism into what we do: thoroughly thought out research would often birth innovations.

Most of the time, society does not encourage research and scientists are hardly self-motivated; promotion criteria in our institutions do not encourage focused, persistent research work that may readily lead to innovations. Rather, we are always in a hurry, we put up policies that do not support strategic research. For example, promotion criteria in some institutions do not

encourage collaborations. So when you invite someone in a group of collaborators, interest of s might be in how sole authored papers would ensue; consequently breaches of agreement result.

Finally, Nematology and fields in Nematology must be introduced or incorporated into curricula in tertiary institutions (universities, polytechnics, monotechnics, colleges of education, etc.) Make the science interesting for students to be attracted to. We need to chart a course for national nematology research, identify challenges ahead and proffer solutions so that we are relevant to environmental management and national development through our research findings.

SUMMARY

The challenge is that we should:

1. Package research results for national development
2. Encourage research continuity and product development
3. Establish linkages and networks, collaboration and documentation
4. Advocate persistence and resilience, traits that are necessary for success in research
5. Have research focus and targets
6. Promote nematology curriculum development and capacity building in nematology: training of nematologists, a must!

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