NEW PESTS CHALLENGING THE CURRENT PEST MANAGEMENT SUPPORT SYSTEM AND NEED FOR REINVIGORATE THE SYSTEM

IPM SUPPORT ETHIOPIA

Proceedings of the 22nd Annual Conference

Edited by

Ermias Shonga

Plant Protection Society of Ethiopia

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The Plant Protection Society of Ethiopia is a society formed by plant protection professionals in the country and is licensed and registered by the Charities and Societies Agency of the Ministry of Justice. The society has been in existence for more than two decades and has been conducting annual conferences every year by picking up a key plant protection issue of a year as a theme. Accordingly, the theme for the 21st annual conference of the Society was **'new pests challenging the current pest management support system and need for reinvigorate the system'.** Papers on the theme were presented by five invited contributors in the plenary session of the 2014 annual conference. Plenary session of the presentations are compiled into this proceedings.

The 21st annual conference was organized by the 2014 and 2015 PPSE executive committee members:

1. Mr Ermias Shonga, President
2. Mr Endale Hailu, Vice President
3. Mr. Gezahegne Getanehe, Secretary
4. Mr. Adane Chofore, Finance Officer
5. Mrs. Mulatwa Wondimu, Treasurer

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ISBN: 978-99944-952-5-2
Correct citation: Ermias Shonga (ed.) 2014. New pests challenging the current pest management support system and need for reinvigorate the system. Proceedings of the 21st Annual Conference, December 25-26, 2014, Addis Ababa.

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Welcome Address

Ermias Shonga
President, Plant Protection Society of Ethiopia

Ato Fikre Markos,
Deputy Director of Plant and Animal Health Regulatory Directorate of the Ministry of Agriculture (MoA) present on behalf of H.E Ato Wondirad Mandefro, State Minister, MoA.

Dr. Fentahun Mengistu,
Director General, Ethiopian Institute of Agricultural Research (EIAR)

Dear Honorable guests,
Conference participants,
Ladies and gentlemen,
On behalf of the Executive Committee and on my own behalf, it gives me a great honor to welcome you all to the 21st Annual conference of the Plant Protection Society of Ethiopia. I would like to thank you all for honoring our invitation and come here from various institutions and long distance.

At the beginning of this year, January 15th 2014, we lost suddenly, our dear colleague and the active member of our society Dr. Emiru Seyume. May I ask you all, for moment of silence in remembrance of Dr. Emiru.

Representative of the state minister
Distinguished gusts,
Ladies and gentlemen,

As you notice, the theme of this year conference is "**NEW PESTS CHALLENGING THE CURRENT PEST MANAGEMENT SUPPORT SYSTEM AND NEED FOR REINVIGORATE THE SYSTEM.**" The Executive committee selected this theme for this year due to two main reasons:

1. The history of plant protection support service in the country is dates back earlier to 1940s with the control of Desert locust. For the last six decades the service was given under the MoA and experienced many success and failure stories. Currently, in our country the pest management research, education pest management support service and extension were highly constrained due to many reasons. Therefore, all the existing and the anticipated problems of the support service should be sorted out and possible policy recommendations are highly demanded from our society.
2. Secondly, in favor of the loosen domestic and national quarantine service and global climate change a number of new insects, plant disease and weed spp. are threatening our Agricultural productivity and challenging the plant protection support system in the country.

To mention some of the pest problems:

The stem and yellow rust on our improved varieties Digalu and Kubsa, the Ginger bacterial wilt which resulted great loss of yield and planting material, Faba bean gall, garlic rot, complex of wilt disease on vegetables, citrus canker, avocados root rot, coffee bacterial wilt and die back, bacterial blight of sesame, virus disease of maize, mealy bug on cotton, white mango scale, resurgence of aphid in most crops, *Tuta abosoluta* on tomato, termite problems in western and southern parts of the country, the most neglected part plant protection is post harvest losses due to pests and mycotoxin development on stored crops. Similarly, the problem of weed spp. on various crops, plantations and natural forests is highly demanding and needs attention.

Therefore, there is a huge work up on us, as plant protection professionals to keep our plants safe from the emerging ravages of pests.

Dear Honorable guests,
Conference participants,
Ladies and gentlemen,
As you can see from the program with you, there are about seven papers to be presented as a theme and sub theme topics.

- Pest Management Support Service System of Ethiopia: Past, Present and Future
- Potential Impacts of Climate Change on Emerging and Re-emerging Plant Diseases and the Need to develop Management Strategies
- The Threat of emerging pests in Ethiopia
- Current Status of Yellow and Stem rust diseases of wheat in Ethiopia
- The role of Mycotoxine in Worldwide food safety
- A high light on the health Hazard of Pesticide applications in Ethiopia
- Agricultural Pesticides use and Handling in Ethiopia

In addition, two pathology papers will be presented as a research finding.

Distinguished conference participants,

It is a pleasure to have with us Ato Fikre Markos on behalf of our Guest of Honor, H.E Ato Wondirad Mandefro to give an opening Address to this national event and to encourage the efforts of our society. We also pleased to have many distinguished and prominent gusts attending this conference. Therefore, the EC of PPSE is highly delighted with all of you coming to this national conference and requests your active participation and fruit full deliberation.

Distinguished conference participants,

I would like to thank all of those who contributed to the success of convening this annual conference. First, I would like to express my gratitude to the DG of EIAR for taking time to be with us this morning to make an introductory remarks and Chairing the opening session. We are sincerely grateful to our donors for their generous financial support. These are:

- The FAO Ethiopia,
- Ministry of Agriculture,
- Ministry of Science and Technology,
- Ethiopian Institute of Agricultural Research ,
- Lions International,
- Assala Malt factory,
- Chemtex PLC.,
- General Chemicals and Trading,
- BASF,
- Koppert Biological System.

We are also great full to different Research Centers; Melkasa, Holetta, Ambo, Kulumsa, and FERC for provision of Vehicles and other facilities to the Executive and Editorial Committee members.

Finally, I will also acknowledge all who have devoted their time and energy to make this conference successful. Before leaving the podium, may I take the honor to request the Director General of EIAR, Dr. Fentahun Mengistu to make an introductory remark and invite Ato Fikre Markos, representative of the state minister to officially open the 21st annual conference of PPSE.

Thank you!

Opening Speech

Ato Fikre Markos
Deputy Director of Plant and Animal Health Regulatory Directorate of the Ministry of Agriculture (MoA)

Dear Conference Organizers
Respected participants,
Invited guests,
Ladies and gentle men,

First of all I would like to express my gratitude to the Plant Protection Society of Ethiopia -PPSE for giving me the opportunity to address this professional gathering at this unique moment in time, where climate change is being globally addressed for environmental and economic concerns. The effect of climate change on the upsurge of pests of agricultural importance is also gaining more attention in corollary with the surfacing out facts around the globe. Moreover, I would also like to commend the organizing committee for coining this timely theme for the 21st annual conference i.e. *"NEW PESTS CHALLENGING THE CURRENT PEST MANAGEMENT SUPPORT SYSTEM AND THE NEED FOR REINVIGORATING IT"*.

Dear Conference Organizers
Respected participants,
Invited guests,
Ladies and gentle men,

I believe you will agree with me that all of us would wish to clearly know what the theme refers to and the scope it covers in the Ethiopian context. In my view pest management in Ethiopia involves predominantly the producer, i.e. the smallholder farmer and the commercial farmer, the plant protection services with their field support services including the plant health clinics, the research and higher learning institutions, and the private sector who supply different types of plant protection products. These stakeholders have different interests and responsibilities. These may be summarized as follows:

The Smallholder farmer

This sector has remained the largest community grouping engaged in agricultural production until the recent past. However, due to lack of appropriate policy the smallholder remained void of using technological advancements and as a consequence was unable to use appropriate pest management practices.

The Plant Protection Organizations

These are organized at the federal and regional governments with two clear categories of responsibilities. These are:

1. Providing extension services in plant protection which mainly covers survey, diagnostic services, training, providing advisory services on pest control and use of different plant protection products and above all providing early warning services on the occurrences of potential pest threats. Moreover, because of the limited capacity of the smallholder to cover financial and material requirements for migratory pests control, the federal plant protection covers the cost of pesticides and spray equipment.
2. Provide regulatory services including Phytosanitary services and the registration and control of pesticides. While providing Phytosanitary services is the responsibility of the federal government, registration and control of pesticides is a shared responsibility of the federal and the regional governments.

The Research and Higher Learning Institutions

These institutions are expected to play the role of generating technologies and produce trained human resource relevant and fit for the services. Agricultural research institutions and universities regardless of their location must be able to come up with solutions to prevailing pest management problems. In this regard Integrated Pest Management innovations are the priority outputs badly needed from the institutions.

The Private sector

This sector is the major input supplier to the smallholder and the commercial farmer. At least from the plant protection point of view it is expected to supply sound and safe pesticides on the right time at an affordable price to the farmers. To that end the private sector need to comply with the international and national pesticide management conventions and laws.

Assessing the relevance of the theme, that is "*New Pests Challenging the Current pest Management Support System and the Need for Reinvigorating it*" implies that either the way the institutions I mentioned earlier, perform their responsibilities is less relevant or less adequate to deal with the new pests. If we agree on such accretion, then it is a plausible recommendation to reinvigorating the system. But which pests are we referring as new pests?

The current immerging pest problems in Ethiopia are, the ginger bacterial wilt, faba bean gall, bacterial wilt of Enset, Garlic white rot, Wilt disease complex in vegetables (peppers, tomato, etc), Citruses canker on Citrus, Avocado root rot; Die back, wilt and bacterial blight in coffee, Bacterial blight of sesame, viruses disease of Maize, are among the many plant disease. Similarly, both food and export commodity crops are highly confronted by insect pest such as: Mealy bug in cotton, Aphids in most crops, Storage pest in pulse crops, white mango scale, tomato leaf miner. Iinvasive weeds like *Parthinum* both in crops and grazing lands, *Prosopis* in Afar region both on crop and range land, *Water hyacinth* in our water body of Rift valley and Lake Tana, Ageratum in Tigray Region, Parasitic weeds (Striga in sorghum and *Orobanche* in pulse and vegetables crops) and Grass weed in cereals and others are relatively new but becoming t challenging for agricultural production in this country.

Crop losses due to these harmful organisms can be substantial and may be prevented, or reduced, by integrated crop protection measures. Therefore, on this regard much work is expected from all stakeholders including professional societies like PPSE and from "Pest Management Support Services" in the country.

Dear Conference Organizers
Respected participants,
Invited guests,
Ladies and gentlemen

I am informed that one of the major issues to be discussed in this conference is the "*Pest management support service*" in the country. In depth analysis and pragmatic recommendations to alleviate the short comings of the system is highly expected.

For the last six decades, the pest management support services has gone through many changes and there could be a number of success and failure stories to tell. The establishment of crop protection at departmental level within the MoA, establishment of plant protection laboratories, plant health clinics and quarantine posts in strategic areas across the country and training of plant protection professionals and technicians at different level were some of the achievements.

The Ministry of Agriculture on its part has started to reorganize itself and is also trying to bring the issue of plant protection as a top development agenda so that federal and regional institutions at all levels can accord it the attention it deserves.

All possible gaps in the pest management support services need to be fully understood by all stakeholders. MoA has been taking actions to reinforce the system. The actions include the relocating of crop protection support system within the MoA by moving it from the extension directorate to the Plant Health Regulatory Directorate (PHRD); assessing, strategic implementation guidelines to promote regular pests management support; incorporation of pest management support service improvement as a sub component in phase II of the Agricultural Growth Program; planning to overhaul the national laboratories, the plant health clinics and the quarantine posts across the country and to improve the human capacity. Accordingly, much is expected from this meeting to identify the existing gaps in pest management support service, thoroughly discuss them and make effective policy options.

I would like to encourage the pesticide industry and companies in Ethiopia to introduce and screen those safer products, with particular emphasis on new generation pesticides for registration and use. This, of course, should be done without excluding generic pesticides that are compatible with IPM programs.

Therefore, a huge task lies ahead of you plant protection professionals in devising and advising all parties on good pest management systems for the diverse needs of our expanding agriculture and providing producers with the relevant information they need.It is my sincere hope that all conference participants will appreciate the subject and strive to contribute towards this in their future endeavour.

Finally, I wish to assure the society that the Ministry of Agriculture is committed to working together and to give support to its level best. Lastly on behalf of H.E Ato Wondirad Mandefro, State Minister, MoA and myself, I would once more like to thank PPSE and Ethiopian Institute of Agricultural Research (EIAR) for co-organizing this important conference. Having said this, I wish you all fruitful deliberations and I know declare that the 21st annual conference of the PPSE is officially opened.

Thank you all!

Review of National Pest Management Support Service System for Ethiopia

Bayeh Mulatu
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Early history of plant protection service in Ethiopia

Although undocumented, pest management in Ethiopia has been going on for millennia by traditional farmers, who have been depending on the use of their indigenous knowledge and practices to manage pests of crops including insect pests, plant diseases, weeds and vertebrate pests. This is evidenced by the presence of genetic resistance in crops like barley (*Hordeum vulgare* L.) from Ethiopia, which has its center of diversity in Ethiopia. For instance Ethiopia provided the only source of resistance to the barley yellow dwarf virus (BYDV) disease in barley (Qualset *et al.*, 1977). Powdery mildew resistance originally retrieved from Ethiopian landraces collected in the 1930s and nowadays controls mildew resistance in the majority of cultivated European spring barley elite varieties (Piffanelli *et al.*, 2004). Resistance to loose smut (*Ustilago nuda* (Jens.) Rostr.) was identified in two introductions of barley (Hordeum vulgare L.) from Ethiopia (cr9973 and cI14099) (Thomas and Metcalfe, 1983). Powdery mildew resistance in barley was also identified in Ethiopian barley germplasms in Germany (Jorgensen, 1992).

Nevertheless, in general, before the 1950s in Ethiopia agriculture was diversified and follows old custom trends in most of the country and farms used to experience extensive crop losses due to pests' damages. In the 1950s the Ministry of Agriculture made great strides in plant pest control and started giving increased attention to other important pests besides the desert locust, which was taken as number one pest affecting crop production in general. Major pest problems which were not formally recognized, at the time, by the Ministry included corn stem borer, pink bollworm, corn earworm, livestock parasites, cutworms, aphids, fruit flies, and a number of plant diseases. Many of these had been observed, but then no organization existed to do experimental or demonstration work. Moreover tools for the development of a pest control program were non-existent, at the time, since no national program had been instituted.

Review of plant protection support service in 1956-87

In 1956 a permanent locust control staff was organized and independently established with a budget and equipment. In same year survey of the armyworm was started by the same group and some control actions were taken to control the armyworm. This situation and developments in the interest of multiple pest problems resulted in the approval of a joint fund for pest control under the Agricultural Cooperative Services Agreement between the United States Operations Mission and the Ethiopian Government. The Project represented a graduated step toward unification of the locust control organization, study of pest problems, demonstration of modern equipment and pesticides, training personnel and pointed toward the establishment of a permanent overall Plant Protection Section within the Ministry of Agriculture (USDA, 1958). In same period the importance of having import, export and domestic plant quarantines was also appreciated and protection of Ethiopian agriculture through quarantines was fully recognized by the Ministry of Agriculture. Moreover, basic plant pest law under which the Ministry of Agriculture could carry out control programs and operate and enforce plant quarantine regulations were developed (USDA, 1958).

The plant protection section within the Ministry of Agriculture was further strengthened by lifting it up to a division level before the 1970's. It was charged with the overall responsibility of the control of insect pests, plant diseases, weeds and vertebrate pests. The monitoring and control of migratory pests as well as epidemic outbreaks of non-migratory pests and plant diseases, which was made the direct responsibility of this division whereas the routine control of regular pests was made the direct responsibility of the farmers and farmers' cooperatives and associations (UNDP/FAO, 1983).

Regarding the management of regular pests, the division was mandated to give guidance and support to farmers through the routine extension service and elaboration and testing of preventive and control procedures. Moreover, national plant protection laboratories were established in 1977 with the objective to provide effective crop protection laboratory and technical support services with adequately equipped, staffed and organized laboratories to provide plant protection services (UNDP/FAO, 1983) so that it would be possible to give support in the following areas: the monitoring and control of major crop pests, diseases and weeds; the implementation of an effective plant quarantine program; evaluate the toxicity and effectiveness of various pesticides; develop procedures and guidelines for the safe disposal, handling, selection and application of pesticides; and develop models for and promote the introduction of cost effective grain storage facilities and techniques

As part of the efforts of the government to respond to the needs to manage multiple economic pests, in 1983 a project funded by UNDP with the primary function of institution building was launched and carried out for four years. Through this project significant changes were made possible in the plant protection division capacity to give pest management and regulation support services (UNDP/FAO 1983).

Review of plant protection support service in 1983-93

In the mid-1980s the division structure was raised to a department level, nevertheless the capacity of the national plant protection support system was inadequately equipped in terms of both support facilities, such as laboratory services, and trained manpower, either to monitor endemic and epidemic pests, diseases and weeds effectively or undertake and promote control measures at the national and local levels. Because of this situation further institution building activities were envisaged and a project to strengthen the crop protection and regulatory department was carried out between 1987 and 1992 (UNDP/FAO, 1987).

By 1987 the Plant Protection and Regulatory Department was divided into 2 Divisions: Crop Protection and Plant Quarantine. The crop Protection division was in turn subdivided into 7 units: Entomology, Plant Pathology, Weeds, Birds and Rodents, Pesticide Chemistry, Pesticide Application, and Storage Problems. Back then the crop protection division had 7 plant health offices in different regions of the country as follows: Bahr Dar (NW), Kambolcha (NE), Jima (SW), Awassa (S), Ziway (S), Goba (S), and Harer (E). It also had scouts and agents, directly accountable to it, at the regional, zonal and district levels. Agents at the district level were responsible for training farmer brigades, whereas those at the zonal level were most involved in control efforts. Agents provided farmers with motorized knapsack sprayers, fuel, and pesticides. The Plant Quarantine Division had units for handling policy and regulations on the import and export of plant materials, operations, and technical aspects of quarantine.

The Crop Protection Division (CPD) was responsible for all research on migratory pests whereas the then Institute of Agricultural Research was responsible for generation of pests control technologies on regular pests. In general, back then, the crop protection division had the following mandates: Provide disease and pest identification services; Provide advisory services for disease and pest control; Administer the plant health clinics and provide technical guidance; Implement pesticide legislation and control; and Identify and develop systems for the safe and efficient use of pesticides

Text Box 1: Pesticide registration and control

The Pesticide Registration and Control Special Decree No. 20/1990 was issued on September 1, 1990. According to this Decree, it is illegal to manufacture, import, sell or use pesticides that are not registered in the country. To register a pesticide in Ethiopia, data on specification, efficacy, toxicology, environmental effects, and residues in food are essential. Pesticide samples, label specimens and other supporting documents are also required. These data are evaluated first by the pesticide sub-committee and then by the Pesticide Advisory Committee. Registration is approved for pesticides that are found to be effective for the intended purpose without undue hazard to the users and the environment (Abdurahman Abdulahi, unpublished report, 1997).

Text Box 2: Plant quarantine services

Plant quarantine service provision in Ethiopia got strengthened by the induction of the plant quarantine regulation in 1992. Moreover through the institution building project Eth/86/042 the team was further strengthened. The project provided trainings, equipment, technical advice, and logistic support to the team at Shola laboratory and the several outlying quarantine stations. By then it was also ascertained that the Ethiopian plant quarantine service was well positioned for further development. It was recommended back then that further support is highly recommended to the long-term consolidation and expansion of the Ethiopian Plant Quarantine Service (UNDP/FAO, 1993a & b).

By 1992 it was confirmed that the crop protection and regulatory department was rated competent with respect to pest and disease monitoring, surveys, identification, and extension and training and in certain cases it was able to provide advice on control (UNDP/FAO, 1993a&b).

Review of plant protection support service 1993 - 2004

The crop protection and regulatory department underwent reorganization and was merged with the crop production department from which the crop production and protection technologies and regulatory department was formed. The crop protection was organized at division level and had three teams working under it: crop protection team, crop protection laboratories and quarantine team and pesticides registration team (MoA, 2000 and Merid Kumssa, 2004). Crop protection related problems recognized by the department at the time include the following:

a) Traditional agricultural practices and the near absence of the use of modern agricultural inputs and technologies
b) Poorly developed pest related data management and lack of capability to make predictions on pest occurrence
c) Research on pests has not been up to the expectation of the department
d) Use of integrated pest management was least emphasized
e) Compounded problems in the invasive weed control programs
f) Weak pesticide registration and regulation system
g) Poor organizational structure preventing the department from providing the needed pest management support services

h) Poor coordination among stakeholders
i) Poor capacity in implementing pest control and regulation related policies, strategies and guidelines
j) Weak human and material capacity
k) Poor supply of pesticide and application equipment
l) Absence of standard pesticide stores and management

Following the appreciation of the above described gaps and problems, the following were set as the strategic objectives of the crop protection division which were thought to make the department more responsive to the increased demands for pest management support by all farmers:

a) Strengthening data collection and early warning system
b) Improving pest management support service system structure and the linkages among the different stakeholders
c) Research on cultural pest control methods and development of integrated pest management and scale up the findings
d) Continually support the research on pest control to come up with new tactics of pest control
e) Support the development of pest prevention and control policies and implement
f) Contain the spread of introduced weed species and control them where they are established
g) Establish properly functioning pesticide registration and control team and strengthen the human and material capacity
h) Improve the provision and distribution of crop pest control equipment and supplies
i) Provide trainings to the crop protection staff working at all levels
j) Modernize the pest data management system of the division

k) Facilitate the plant protection laboratories to make them more responsive to the increasing demands for pest management support services
l) Fasten the process of disposal of obsolete pesticides, containers and malfunctioning spray equipment
m) Put in place standard pesticide stores and stock quality assured pesticides and application equipment
m) Facilitate the provision of loans to farmers to help them use pesticides and other production boosting external inputs

Review of plant protection 2005-2008:

The Ministry of Agriculture was reorganized in 2004 and renamed the Ministry of Agriculture and Rural Development (MOARD). Accordingly the crop protection was separated from the production and was put under a new directorate Animal and Plant Health Regulatory Directorate (APHRD). The mandate of the APHRD was revised and made to include all measures necessary to: conduct quarantine controls on plants, seeds, animals and animal products; and prevent outbreaks of animal diseases and plant pests. The Plant Protection Division organization was similar to the previous arrangement. As the national plant protection organization (NPPO) of Ethiopia it had the following three divisions:

Pesticide Registration and Control Team: The team was composed of a few experts mainly tasked with registering agricultural inputs. They operate under the Pesticide Registration Decree No. 20/1990 which regulates pesticide import permits;

Crop Protection Laboratories and Quarantine Team: This team was responsible for ensuring that all imported and exported agricultural products are inspected and verified as free of any injurious insects, pests, diseases and noxious weeds of quarantine importance. With a federal mandate, the team had been overseeing the functioning of a number of quarantine stations. The stations functioning at the time were those at Bole Airport, Dire Dawa, Metema, Moyale and Nazareth (Central Rift Valley). Among these, it was only the Bole Airport and Moyale stations that used to carry out import inspections. The rest were performing only inspections for export;

Crop Protection Division/Team: This division has been responsible in controlling migratory pests such as the African Army worm, locusts and the quelea bird. It has a federal mandate as it looks only at transregional issues.

This period also corresponded with the conduct of the Plan for Accelerated and Sustainable Development to End Poverty (PASDEP) 2005-2010 (MoA, 2006). Interventions in crop protection that were planned for the PASDEP included:

1. Capacity building through training of farmers on pests and plant protection measures raising the professional strength of crop protection personnel at all levels;
2. Improving laboratory facilities technical equipment for rendering the required effective services;
3. Development of pest monitoring and early warning system, establishing field monitoring stations, strengthening pest trap sites, deploying pest monitoring staff/scouts;

4. Establishment of information networks to track pest development to communicate to appropriate federal and regional authorities for appropriate action;
5. Field surveys and pest control operation to ensure readiness to act against any threatening pest situation through procurement and storage of pesticide and spraying equipment in advance, and ensuring availability of logistic support;
6. Promoting integrated pest management, which is both less costly and more environmentally-friendly;
7. Plant quarantine and inspection service: - establishing and/or strengthening quarantine stations to monitor and control pest movement at entry points;
8. Harmonization of regulations for plant quarantine, pesticides registration and control of bio-pesticide.
9. Post-harvest loss management: developing and disseminating extension packages and promoting improved storage structures and practices.

Review of plant protection 2008-2013:

In 2008 there was a total shift in the thinking and direction of the Ministry of Agriculture and Rural Development on the ways and how of providing pest management support services in the country at large. This happened following the introduction of *"Business Process Reengineering"* a thinking accepted as a way that could help the MoARD respond better to customers' needs. It was said to be a better approach in providing the requested services faster, in quality, with enough alternatives to choose from, and delivering them at reduced cost. To this effect the new approach partly required that services delivery process (work flow) be shortened and also the structure be compressed vertically and horizontally by canceling some process steps and downsizing of the workforces needed to deliver the services. In line with this, the crop protection and regulatory directorate was subdivided and the pesticides registration and control, migratory pest control support and the pest regulatory components were maintained within the Animal and Plant Health Regulatory Directorate, which was officially operating following the previous restructuring. And the pest management support service intended to manage regular pests was significantly reduced and transferred to the extension directorate. Following this arrangement and due to the generalist concept **"one will do it all"** that was being promoted in the BPR process, the major disciplines in crop protection that used to be handled by different experts (entomologists, plant pathologists, weed scientists, vertebrate pests control experts, pesticides application experts) were removed from the structure and all the responsibilities to deal with these different aspects was given to one expert to handle. This arrangement was adopted by all the regions, zones and woredas across the country.

Review of crop protection technologies generation and transfer

Crop protection information, knowledge and technologies generation dates back to the 1940s, which was carried out by Italians, followed by the MoA and the then Alemaya University (Hramaya University) in the early 1960s. These early activities were focused on generation of information and knowledge through surveys.

Plant protection research has been going on, in an organized way, since the establishment of the then Institute of Agricultural Research (IAR) since 1966. The researches at the beginning were focused on plant pathology and entomology. Research in weed control began in 1969 in Agronomy section where herbicides efficacy evaluation was the main area focus. Since 1971 and until the beginning of the 1990s weed research was included in plant protection then after it was taken back and integrated with Agronomy research. Research on vertebrate pests control began latter but terminated in 1988 and transferred to MoA at the then Shola laboratory. The latter inclusions into the division were plant quarantine and seed health research. The disciplines except the vertebrate pest control research are still up and running actively.

In the course of its existence, plant protection research underwent a number of organizational changes. At the start and for some years afterwards it was running under crop protection department. Following this, the researchers in crop protection were assigned and had been working in different crops teams with other professionals (Breeders, Agronomists, Soil Fertility Experts, Socio Economists, Research Extension experts). Currently the research in plant protection is restructured in such a way that plant protection research activities were directed and coordinated at Ambo Plant Protection Center. Nevertheless in the course of all these reorganizations the research outputs from plant protection disciplines have been declining significantly.

Although the then IAR was the main institution until 1992 generating crop protection technologies, its linkage with the crop protection division/department of the MoA had been recognized to be very poor. To date this has not changed significantly and the linkage between the two has remained loose. This is despite the fact that technology generating institutions have increased in their number and include EIAR, RARIs and Universities that have been producing graduates in agricultural fields including crop protection.

In the 2005 Plant Protection Society of Ethiopia annual conference the increase in the number of crop protection professionals in the country was recognized to be significant. Nevertheless since 2005 the number of post graduate students in plant protection has declined significantly showing that despite the increase challenge coming from migratory, regular and newly establishing pests, the number of plant protection professional joining the work force is decreasing. This is further complicated by the severe shortage of trained manpower at the grass root level, which could provide crop protection technology transfer services to all who need it.

Regarding the generated and transferred crop protection technologies; the first modern technology promoted was the use of synthetic pesticides. Accordingly evaluation of insecticides, fungicides, herbicides and rodenticides started in the early years of the existence of the then Institute of Agricultural Research (IAR). The first organized manual on recommended insecticides was published by IAR (Crowe and Shitaye, 1970). This happened after the time when the side effects of the use of insecticides in agriculture and public health were fully recognized by Entomologists of the time in North America (PNAS, 1969). However, to the present date synthetic insecticides have remained to be very important in managing pests on crops being grown in many areas across the country. In general, since the establishment of IAR in 1966 and further expansion of the National Agricultural Research System, much crop protection related research activities have been undertaken, and they fall into the following categories:

1. Survey, collection, identification and documentation of pests of major crops
2. Determination of yield loss for key pests of food and industrial crops
3. Chemical control studies against major economic pests
4. Determination of economic threshold levels for application of pesticides
5. Cultural control studies on major pests;
6. Physical control studies on major pests;
7. Host plant resistance studies;
8. Botanical control studies on field and storage pests
9. Studies on biological control of insect pests
10. Development of integrated pest management on key pest species.

The research outputs from the early years used to be published in annual progress reports and used to be presented in the National Crops Improvement Conference (NCIC) annual conferences. These reports, however, had limited circulation and were not reaching all potential users of crop protection information sources at the time. Useable technologies in entomology, plant pathology and weed science used to be published in leaflets, technical bulletins and monographs. Moreover, the first crop protection focused research outputs review in Ethiopia was held in 1985 (Tsedeke Abate, 1985).

This was conducted about thirty-five years after crop protection was started in the country.

Although there were research outputs on identification of pests, estimation of associated yield loss to the damages by the major pests and different pest control methods including cultural, chemical and host plant resistance, none of the 39 contributions to the review conference presented any recommendation on any of the reviewed pests regarding the issue of integrated pest management. The major outputs, however, were different effective pesticides that could effectively control the different major pests; when applied at predetermined rates of application and defined number of rounds of spray.

At the finalization of the first crop protection review conference discussion was held to get reflections of crop protection technology users regarding the pest management technical information they had been receiving. The discussant form the MoA, back then, described that through its crop protection laboratories, the MoA had been providing pest management support services to small scale farmers and had been using recommendation given by the research system directly, which was by-and-large focused on pesticides use. Then it was underscored fully that in the country at large the use of pesticides had not been properly managed and there were no legislations, at the time, regarding pesticide usage hence in 1985 legislation on pesticide use was drafted and presented to the council of Ministers.

Twenty years were lapsed following the 1985 crop protection research achievements review and before another review conference was organized. The Plant Protection Society of Ethiopia instead of the Ethiopian Institute of Agricultural Research took the initiative and organized the second crop protection research achievements review conference in 2005. The proceedings of the conference were produced in two volumes. In this conference it was concluded that although single control method focused activities have been the major focus such as screening of pesticides or germplasms, there were identified IPM packages for a number of pests such as stalk borer of maize, bean fly, barley shootfly, tomato fruit worms, grass weeds. Nevertheless generated plant protection technologies have not been fully utilized and plant protection related technologies and knowledge transfer to development actors and the farmers have not improved significantly. Available venues like farmers field schools have not been utilized to demonstrate effective technologies and also to teach farmers.

Review of provision of trainings in crop protection

One of the main focuses of the MoA had been the provision of trainings based on assessment of pre- and in-service training needs of field staff, preparation of training programs and materials and also conducting the trainings. Technologies, information and knowledge that have been generated by the research system have been compiled into crop production packages' components and have been delivered to users in different training fora.

As described earlier until the 1950s the significance of pest control was not known and there were no institutions put in place to provide such services. But, it was then that provision of training to farmers was fully appreciated and introducing to farmers of current ways of pest management, particularly, pesticides was given due attention. Production and distribution of training materials and provision of trainings to development agents has been followed by the MoA for more than six decades, i.e., years before the start of the "Minimum Package Program" in 1971.

Regarding the training materials that have been prepared and in use to train the field staff, they were found to be many, nevertheless, locating most of them was found to be very difficult. The latest documents that have been accessed and reviewed include the Plant Protection Guideline produced by EIAR in 2009 and various training documents prepared by plant protection experts working in the MoA, the regional bureaus of agriculture, major crops production packages training manuals and pest control leaflets produced by EIAR, the Plant Protection Society of Ethiopia and the MoA. Most of the training materials were not published and are all in the holdings of the experts who either prepared or revised them.

From these documents it was possible to understand that the pest management practices on the different crops and pest combinations prepared and communicated could be generalized into the following: (i) use of host plant resistance and minimum use of fungicides to manage fungal diseases; (ii) use of chemical insecticides based on damage information and some cultural practices to manage insect pests; (iii) use of crop rotation, fallowing, critically timed hand weeding, depending on available labour and/or use of herbicides to manage broadleaved and grass weeds. Therefore, it can be stated that although there are included in the packages different recommended management practices that include the use of cultural, physical, host plant resistance and pesticides for different pests; the recommendations did not often include verified and confirmed integrated pest management practices.

Current situation of provision of pest management support services in Ethiopia

The pest management support service that was split between the APHRD and the Extension directorates was found to be an impediment to the provision of effective support service to farmers. Currently it was fully recognized that the pest management support service structure that was operating until the beginning of 2014 has not been found to be responsive in helping the control of regular and migratory pests and also newly establishing quarantine pests. In response to this situation, currently the MoA reorganized the pest management support service structure and established Plant Health Regulatory Directorate General (PHRD) with three directorates: Crop Protection, Plant Quarantine and Seed Health and Quality Regulatory directorates. The extension directorate has transferred its responsibility of supporting the management of regular pests to the PHRD.

The current mandates of the PHRD and the Extension service support directorate with regard to the provision of pest management support services are the following: the extension service support directorate receives all the necessary technical backstopping in plant protection from the PHRD while providing trainings to experts on major economic crops production packages whereas the crop protection directorate provides all supports in the management of migratory and regular pests. Moreover the latter involves in the containment and management of newly introduced and established pests and pests of quarantine importance. The PHRD has put its strategic goal, objectives and the major activities it deals with and are described below:

Strategic goal:

- Effective national system to keep plant health and quality and run regulatory works on seeds, pests and pesticides developed and regularly improved

Strategic objectives:

1. To give rapid and quality inspection and certification service
2. To provide rapid and quality inputs evaluation, registration and quality control
3. To deliver rapid and quality pests control service on regular and migratory pests
4. To facilitate the implementation of basic procedures for the regulation of modern agriculture
5. To improve the timely dissemination of information sources applicable to the accomplishment of the tasks of the directorate
6. To strengthen the skill and knowledge base for discharging regulatory activities effectively

Major activities:

1. Providing health certificate for plant and plant products destined for export based on requirements of target countries
2. Provide import permit for plant and plant products and related inputs to be imported into the country
3. Provide goodness of fit certificates for products and services that fall within the inspection and certification case team
4. Conduct risk assessment on plant, plant products and other inputs to be imported to the country
5. Provide risk assessment related information on plant and plant products destined for export based on requirements from importing countries
6. Conduct surveillance, survey, monitoring and control of regular and migratory pests
7. Prepare necessary regulatory documents relevant to the directorate
8. Establish working procedures, conduct monitoring and develop guidelines
9. Provide training opportunities on current issues to regional bureaus of agriculture and other stakeholders
10. Improve timely information delivery
11. Develop the professional capacity of the staff of the directorate

Current organizational structure of crop protection

As described earlier there was a direct structural link between the plant health clinics and the crop protection department in the MoA. This was terminated and the plant health clinics were made directly accountable to the Regional Bureaus of Agriculture in the respective regions wherein they are located. The crop protection experts in the extension directorates of the MoA and regional agricultural bureaus were loosely connected with the APHRD and the plant health clinics. The structure in the research system completely disregarded crop protection research and gave it the lowest possible emphases. This was done by totally reorganizing the only plant protection research center in the country and reducing its coordination capacity by putting plant protection research under biotechnology research.

In general both in the agricultural research and development there is clear evidence of structural problem at the federal and regional levels, which has affected the capacity building in the pest management support service due to mainly critical shortage of funds/budget appropriated to the conduct of the support service and the absence of critical number of experts who could provide the services as needed. The consequence of this was that the packages provided to development agents and farmers were incomplete and hence contributed to a number of regular pests to cause significant economic damage on the crops of their choices. As described above this has caused the unregulated use of pesticides by farmers and the wider circulation of unhealthy planting materials, thus yield and quality of crops produced have been significantly compromised.

Current situation of crop protection experts

There has been lack of comprehensive organizational setup for plant protection experts to feel comfortable in, an incentive mechanism rewarding them to what they have been doing and to remain in their work position. The lack of recognition of their significance is expressed by the lower professional position at which crop protection experts have been assigned to work unlike their equals working in agronomy or crop production. Apparently there has been lack of proper awareness on the side of decision makers, at all levels, regarding the level of significance of conducting pest surveillance, survey, monitoring and control on regular pests hence their experts are sought only when there was pest outbreak of one sort or another.

Current situation of crop protection laboratories

There used to be well equipped and staffed crop protection related laboratories in the Ministry of Agriculture. Due to the reduced attention plant protection support service received after 2008 all the laboratories were closedown and at the moment the experts are not providing the needed technical supports based on diagnostic information. Lately there is an activity going on in the MoA to bring these laboratories back into operation, but the process is moving at a very slow pace. What is worse is that the plant health clinics and quarantine posts present across the country have been operating very poorly.

The main problems the PHCs have been facing include: low support they have been receiving from development projects like the AGP, lack of staff who could work in the different disciplines (entomology, plant pathology, weed science, vertebrate pests, and quarantine and seed health), the laboratory facilities and guidelines they have been using are all old and outdated, the internal facilities at the PHCs are incomplete and in bad shape because there has not been any replenishment since their establishment, there is generally critical shortage of budget and logistic. These are further complicated by the lack of transportation facilities to conduct pest surveillance, survey and monitoring. The available quarantine facilities are very poor and are not in position to protect the country from potential pests coming from other countries and between regions in the country.

Current situation of training in crop protection

Crop protection recommendations on economic pests are normally incorporated in the crop production packages, however due to the low emphasis given to pest management in the packages, the following gaps were created during practical implementation of acquired knowledge:

1. Failure by trainers to communicate the full picture of economic pests and the corresponding management information,
2. Miss communication of crop protection related information to users,
3. Miss identification of pests and wrong recommendations provided to farmers who sought technical support on pests causing significant economic damage on their crops,
4. Prevented development agents from getting sufficient knowledge on pest management strategies and tactics.

Because of these, there is insufficient current knowledge in pest management in the actors involved at all levels of the agriculture development. The cause for these is the absence of fully-fledged pest management support service system, which brought the following:

- Known economic pests have not been routinely surveyed, monitored and their current status have not been properly communicated;
- Informed pest management control decisions are not being exercised rather the system has been responding to emerging problems in a tactical than strategic manner;

- Pest management has been largely dependent on the uncontrolled use of generic pesticides. Other practices have not been receiving sufficient attention.

Due to these, there is upsurge of regular pests, establishment and spread of new pests, development of pesticide resistance in major economic pests due to mainly misuse of pesticides and pest, which had local importance have turned a national problem.

Current situation of quarantine service provision in Ethiopia

Addressing pest regulatory issues using the countries system and procedures is very apparent at the federal level but it is focused only on promoting or facilitating the export and import of agricultural produces. Nevertheless, enforcement of phytosanitary measures has been constrained by a number of things such as shortage of enough trained personnel, physical capacity, and lack of phytosanitary law. Besides, the regulatory directorate has not been organized in such a way that it can give rapid response to arising plant quarantine related problems. Moreover, there are no enough resources to do pest risk assessment as needed due to lack of well documented check list of quarantine pests to Ethiopia and expertise to do the job as needed. In general pest risk assessment for quarantine decision making must be done professionally by learning what has gone wrong with the carmine cochineal, which is currently devastating cactus pear, an important fruit and feed source for many in Tigray region.

Although regulating the movement of plant materials across the country was long recognized as an important activity, to date there is no domestic quarantine system put in place to regulate the movement of plant materials across the country. Due to the failure of the pest management support service system to provide domestic quarantine service a number of pests have found their ways to newer areas in different parts of the country and have been causing significant economic damage to different crops this include virus diseases on sweet potato, bacterial wilt on potato, rotting fungi on garlic and onion, woolly apple aphid on apple, cotton mealybug on cotton and mango white scale on mango and quite recently the South American tomato fruit worm, *Tuta absoluta*. In general the issue of domestic quarantine has not been given the utmost attentions by all concerned as there are no directives, to date, for the implementation of domestic quarantine system in order to avoid similar crises from happening.

Available national policy, strategy, regulations and directives on PMSS and IPM

There are supporting national policies, strategies, regulations and directives on pest management support service and pest management in general, which have been considered in different regulations and decrees. These include the following:

1. The plant quarantine regulation of 1971 Decree number 56 empowers the Ministry of Agriculture to control pests and diseases in the country and prevent their entry from other countries. Review of plant quarantine structure and capabilities to establish plant quarantine post entry stations and prepare draft national plant quarantine legislation was made in 1984. This allowed the 1971

decree to be updated and for the council of Minister to issue updated and improved plant quarantine regulation in 1992.

2. Pesticide Registration and Control Special Decree was issued in September 1990. This requires generation of local efficacy data by a recognized Research Institute in order to get a pesticide registered in the country. The Decree was believed to have given protection to farmers from procuring pesticides from unscrupulous sources and whose efficacy is not known. This took place after the draft legislation for pesticide registration and regulation and also pesticide disposal regulation were drafted in 1984.
3. The special decree above was replaced by another one no. 674/2010. This aims at minimizing the adverse effects that pesticide use might cause to human beings, animals, plants and the environment. This comprehensive legislation was passed to regulate the manufacture, formulation, import, export, transport, storage, distribution, sale, use and disposal of pesticides and other matters related thereto.
4. The "National Agricultural Research Policy and Strategy" issued in October 1994 states the type of plant protection research that has to be conducted in the country. Research that will minimize adverse effects of pesticides on the environment, pest resistant variety development, finding solutions for pest outbreaks are to receive the necessary attention.
5. In the Policy and Investment Framework (PIF), strategic objective 1 (SO1) aims to achieve a sustainable increase in agricultural productivity. To this end, beside a number of technologies that help increase production and productivity; weed and pest control are included as important factor that should be dealt with in order to achieve SO1.

Although there has not been any documented policy, strategy and directives, regarding institutionalizing of IPM in the regular pest management support system and on how to promote IPM in the country at large, the government of Ethiopia started advocating the importance of implementing IPM in the country in the 1980s. Nevertheless its promotion has been very slow and limited success stories are available regarding IPM implementation (Ferdu Azerefegne and Tsedeke Abate, 2007).

Experiences of PHRD in providing IPM related support service

In anticipation to know the implementation status of IPM in Ethiopia a survey was conducted by Fantahun et al. (2003). The team found out that in general there was least emphasis given by GOs and NGOs towards IPM initiatives and implementations. The survey team identified the following gaps: absence of national IPM policy/strategy and framework; lack of effective coordination, collaboration and networking mechanism in IPM implementation; there was low level of awareness by policy and decision makers of the relevance of IPM; and there was also insufficient infrastructure put in place for IPM implementation in the country. This was also complemented by Eshetu Bekele and Ferdu Azerefegn, 2005 and Eshetu Bekele et al., 2006).

Pesticide Action Nexus-Ethiopia (PAN-Ethiopia) together with the Institute of Sustainable Development (ISD) organized an advocacy workshop on IPM implementation in Ethiopia (Tadesse Amera and Asferachew Abate, 2008). The workshop participants agreed that even if there are trials of IPM framework development and implementation in dispersed ways, the documents produced and the main gaps are not organized and available as a resource. They agreed and formed a task force among different stakeholders that could assess available IPM framework documents attempted by different stakeholders, identify the gaps and lobby for the preparation of a draft IPM framework document. The task force was also given the assignment to discuss with authorities in the MoA for the possibility of drafting a national IPM policy. Nevertheless no follow-up work or action has been taken, to date by the advocacy group.

Implemented IPM practices

There are limited IPM practices implemented in the country; some IPM recommendations implemented on the ground that could be cited include: the integrated late blight management on potato in West Shewa zone of Oromia region (Abraham, 2009), integrated bacterial wilt management on potato in the Amhara region (ARARI, ???), integrated cotton pests management in cotton in Arba Minch area (Tadesse Amera, 2008), integrated management of chafer grubs on barley in western Shewa (Bayeh, unpublished data, 2001), integrated management of diamond back moth on cabbage in eastern Shewa (Mohammed *et al.*, 2006), integrated management of enset mealybug (Ferdu *et al.*, 2009) and integrated fruit fly management in Upper Awash and integrated management of maize stalk borer on maize (Ferdu, ???), and integrated grass weeds management on wheat in Bale (Rezene *et al.*, 2003).

The implementations of the IPM practices on the diseases were conducted in small scale farmers' fields with direct involvement of farmers who were organized into IDM-FFS. The insect pests IPM practices were mainly implemented on small scale farms using IPM-FFS approach or in a large scale farm at Upper Awash and Bale Agricultural Enterprise by involving the experts. However, the successful adoption and sustenance of these initiatives has not been evaluated and documented, to date.

Conclusions from past and current pest management support service provisions

1. There have been repeated reorganizations of the system that took place since pest management support service provision began in the country. All through the time, efforts were made to improve the system to make it more responsive to the needs of farmers requested at the time. But, the capacity of the system to cope with the increased demand for support, duet to the ever expanding rain fed and irrigation schemes in the country, was very low. It is very clear that the PMSS did not expand as it should in order to become competent enough and address all pest problem related demands coming from farmers.
2. From the current situation review what was found to be the most important issue is creating awareness in the top management at different levels of the MoA about the significance of properly institutionalizing pest management support system for migratory, regular and quarantine pests. Because of the repeated challenges coming from economic pests of major crops in the country, the leaders of institutions relevant to the promotion of better agriculture in the country have now fully realized that the pest management support service system needs to be reinvigorated. As shown clearly in the current situation analysis, this requires doing a strong capacity building in the area of plant protection in order to provide plant protection support services as required and to ensure transfer of crop

protection technologies to all who need the support. This can be done by accommodating all stakeholders. In this process special attention should be given to the facilitation of the federal plant protection laboratories and the PHCs as they were developed to provide the service of pest management. Strengthening the PHCs will help them successfully carry out surveillance, survey and monitoring on regular pests in order to help farmers decide to control a regular pest only when found appropriate.

3. National plant protection laboratories are not operational at the moment. They should be reorganized in such a way that they will be of significant help to the PHCs and the quarantine facilities present across the country. The MoA should, therefore, capacitate the national plant protection laboratories, PHCs and quarantine facilities by making available enough funding to improve their internal facilities, employing enough staff to work in the different disciplines (entomology, plant pathology, weed science, virology, nematology, vertebrate pests, pesticide science, biological control, IPM); forging strong relationship between the national laboratories, plant health clinics, quarantine facilities and users of the service, Agricultural Universities, Research Institutes, other sector organizations and different national mega projects such as the AGP, ATA, EAAP).

   When the national plant protection laboratories, PHCs and quarantine facilities are fully capacitated then exchange of pest surveillance, survey and monitoring data nationwide will be improved significantly with the national plant protection laboratories serving as anchoring bodies. Moreover, plant quarantine activities will be conducted better. Until this becomes possible the national plant protection laboratories should be made operational using available facilities and human resource without any further delay.

4. It is not only the available quarantine facilities are upgraded, but their number be increased and policy gaps related to quarantine should also be made complete, i.e., fill the gaps of legal issues to strengthen the domestic quarantine system that could ensure the transfer of healthy plant materials between places within the country borders.
5. Available guidelines and regulations on import, distribution and use of pesticides, seeds and other inputs should be implemented fully so that further crises related to the introduction and establishment of alien pests could be prevented, accumulation of obsolete pesticides and other expired external inputs could be avoided. From the current experience there is an urgent need to device and introduce a seed certification system to guarantee that planting materials being exchanged within the country are healthy and of the required quality.
6. Pest risk assessment for quarantine decision making is very important and has to be done professionally by learning what has gone wrong with the cochineal introduction, which is currently devastating cactus pear, an important fruit and feed source for many in the Tigray region.
7. Currently training materials that have been prepared and trainings delivered to crop experts and development agents in the MoA have been giving least emphases on pest management issues. Therefore, revising the packages and incorporating crop protection related contents as required needs to be given the utmost attention. While providing trainings to crop protection staff from federal to kebele levels due attention has to be paid to the significance of promoting integrated pest management.
8. The national agricultural research system should also give the required emphases on addressing pest problems and come up with recommendations that could be used by farmers. The research system should focus on promoting IPM in the crop production system at large.
9. There are problems with the promotion of alternatives to the use of pesticides such as introducing biological control agents into the farming system, except in the protected agriculture. This is due to lack

of national policy and strategy for its promotion and the stringent policy being followed by the EPA, which for instance has delayed the release of Zygograma, a bio control agent known for its success in checking parthenium elsewhere, which was found, through host specificity testing done at PPRC, to be highly specific to parhtenium.

In general the pest management support service system full situations have been fully understood by decision makers in the MoA and actions have been taken to reinvigorate the pest management support system. The actions include restructuring and relocating of crop protection support system within the MoA and drafting of policy, strategy and implementation guidelines to promote regular pests management support. The relocating of regular pest management from the extension directorate to the Plant Health Regulatory Directorate (PHRD) has already been done. The restructuring of the PHRD is progressing very well with the approval and implementation of organizational structure. In order to benefit from the created favorable environment it is essential that needed policy directions, pest management strategy and implementation guidelines be put in place.

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Potential Influence of Climate Change on Emerging and Re-emerging Plant Diseases and their Management Strategies

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Abstract

Climate changes are in response to changes in the hydrosphere, biosphere and other atmospheric and interacting factors and are considered one of humankind's greatest challenges in the near future. Once the environment determines the occurrence of diseases, climate change can modify and influence the incidence as well as temporal and spatial distribution of plant diseases. The environmental change, especially when combined with pathogen and host introductions, may result in unprecedented effects. Climate change can lead to re-emergence of pre-existing pathogens or can provide the climatic conditions required for pathogens to emerge in agriculture. It can also cause alterations in the disease geographical and temporal distributions and consequently the management methods will have to be adapted to this new reality. As a consequence of all these potential impacts of climate change on plant diseases and their associated causal agents, it appears that future climate change challenges will not be met by single disease management practices, but by a mix of different approaches adapted to different situations. This paper discusses different aspects related to the potential impacts of climate change on the emergence and re-emergence of plant diseases and the need to develop strategies with multifaceted tactics that are based on epidemiology of the pathogens in point for long-term adaptation and insurance in agriculture.

Keywords: Climate change, emergence, management strategies, plant diseases, re-emergence

Introduction

Agriculture is strongly influenced by weather and climate. While farmers are often flexible in dealing with weather and year-to-year variability, there is nevertheless a high degree of adaptation to the local climate in the form of established infrastructure, local farming practice and individual experience. Climate change can therefore be expected to influence agriculture, potentially threatening established aspects of farming systems but also providing opportunities for improvements (Jemma *et al.*, 2010).

Plant diseases are often the most important constraints to crop production. They indirectly reduce yields by debilitating the plant, and directly reduce the yield or quality of fruit before and after they are harvested. They range from esthetic problems that lower the marketability of the harvested product to lethal problems that devastate local or regional production. Diseases determine how and where a crop is produced, what post-harvest treatments are utilized, in what markets the crops are sold, and whether production is sustainable and profitable. Plant disease is broadly defined as any condition in which a plant exhibits some malfunction or abnormality in its growth or development (Agrios, 2005). The distinction between healthy and diseased plants may be extremely fine, but usually alterations in the physiological or morphological development are such that the unhealthy or diseased individual is obvious by appearance. If a plant does not produce or develop according to normal expectations, it is considered diseased.

Plant diseases are generally grouped into two categories based on their causes; .biotic (Infectious) and abiotic (Non-infectious). Parasitic

(Infectious) diseases; are caused by infection of the host plant by microorganisms or other pathogens which derive their food by growing on or in other plants. The most common causes of parasitic diseases are fungi, bacteria, phytoplasmas, viruses, nematodes, and seed producing (Phanerogamic) parasitic plants (Dodder (*Cuscuta* spp.),Witch weed (*Striga* spp.) (*Striga* spp.), Broomrapes *(Arceuthobium* spp.*)* and Mistletoes (*Arceuthobium* spp.) (Brown and Hovmøller, 2002).

Infectious disease transmission should be viewed within an ecological framework. During the long processes of human cultural evolution; population dispersal around the world; and subsequent inter-population contact and conflict, climate change and several distinct transitions in human ecology and inter-population interactions have changed profoundly the patterns of infectious disease in plant populations (McNeil, W.H., 1976).

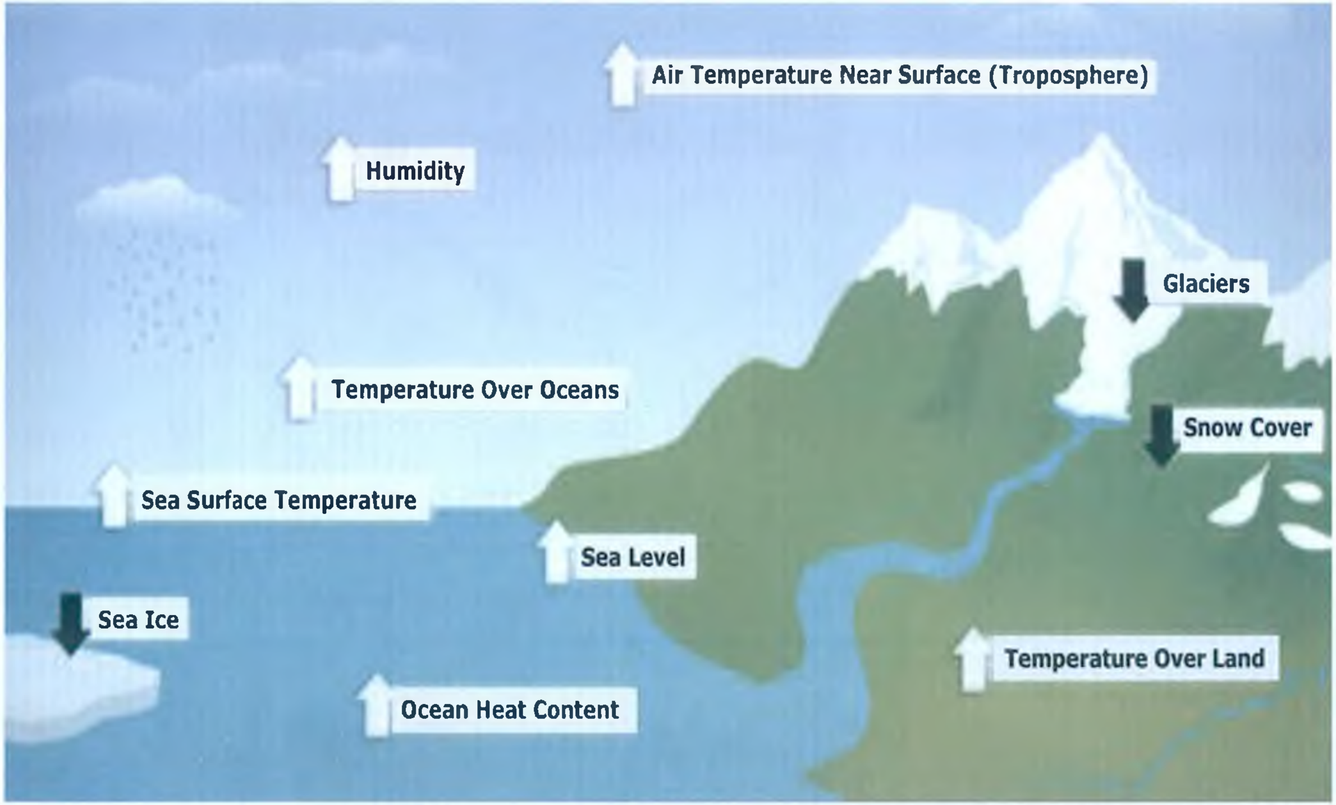
On the other hand, non-parasitic (non-contagious) diseases are caused by unfavorable meteorological factors, status of soil moisture, nutritional disorders, atmospheric impurities and improper cultural practices (Anderson, 2011).

The influence of plant disease can be stark, famine can result if no systems are in place to replace lost crops. Notorious famines precipitated by plant diseases include the Irish potato famine of the 1840s due to potato late blight, the Bengal famine of 1943 due to rice brown spot and famines in Uganda in the 1990s due to cassava mosaic virus disease. Whole ecosystems can be altered when ecologically important plant species are decimated by invasive pathogens with which they have not coevolved (Garrett, 2008).

The purpose of this paper is to highlight some of the evidences linking changes in climatic factors such as temperature, precipitation and atmospheric impurities, to most economically important emerging and re-emerging plant diseases in Ethiopia and their associations via ecological processes.

Climate change and plant diseases

Climate changes are changes in response to changes in the hydrosphere (seas, oceans and water in the atmosphere), Biosphere (planet Earth and its life),other atmospheric and interacting factors and as a result of human activities (Wikipedia, 2010) (Figure 1). Human activities driven by demographic, economic, technological and social changes have a major impact on climate change (Garrett, 2008). The climate influences the incidence as well as temporal and spatial distribution of plant diseases.



Source: Wikipedia, 2010

Figure 1. Ten Indicators of Global Warming

The main factors that control growth and development of diseases are temperature, light and water. The climate change affects the survival, vigor, rate of multiplication, sporulation, direction, and distance of dispersal of inoculums, rate of spore germination and penetration of pathogens. Climate affects all life stages of the pathogen and host and clearly poses a challenge to many pathosystems (Evans, 2007). The environmental change, especially when combined with pathogen and host introductions, may result in unprecedented effects (Jeger *et al.*, 2011) Climate change will result in rise in: Surface Temperature (global warming (Figure 1)), Moisture (surface water and precipitation) and Atmospheric impurities (SO_2 , $2NO_2$,CO_2) (Figure 2) (Brasier & Webber, 2010).

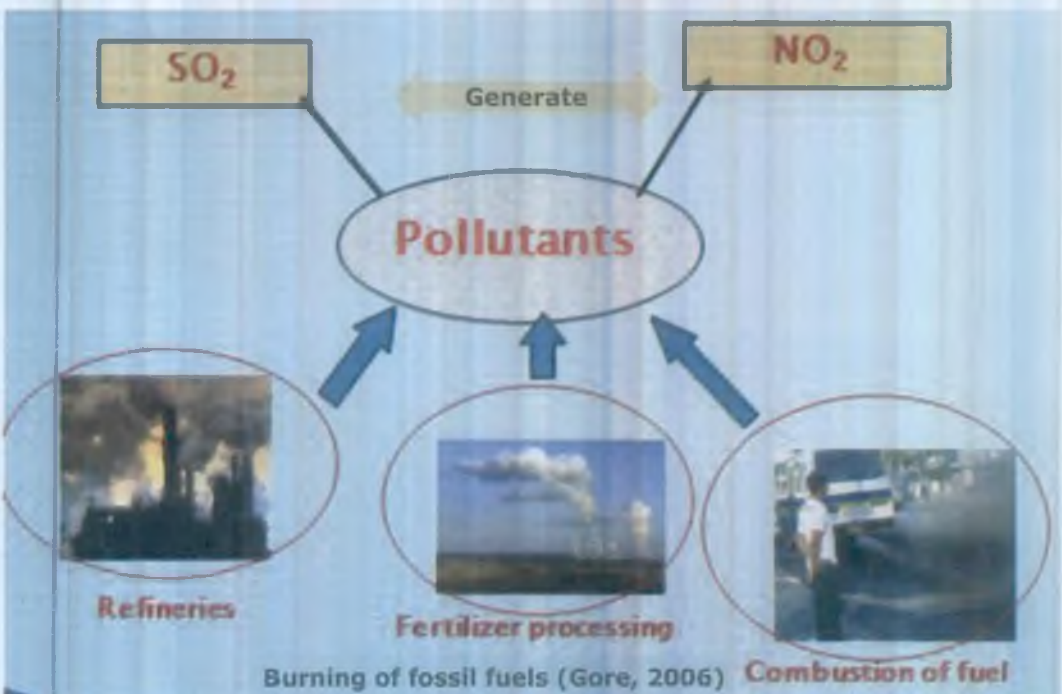


Figure 2. Major pollutants in the atmosphere and their sources

Industrial activity, from the burning of fossil fuels such as coal, oil, and gas, generates CO_2 and other gases which trap the sun's ray in the atmosphere and enhance the natural "greenhouse effect" (Gore, 2006). Climate change is the biggest threat to mankind, and is the cause of nearly 0.4 million deaths a year worldwide and costing the world more than US$ 1.2 trillion. Climate change is affecting our agriculture due to 0.74°C average global increase in temperature in the last 100 years and atmospheric CO_2 concentration increase from 280 ppm in 1750 to 400 ppm in 2012 (Rayees et al.,2013). Such changes will have a drastic effect on the growth and cultivation of the different crops on the Earth.

Influence of climate change on plant diseases

The effects of climate change may be on the pathogen, the host or the host-pathogen interaction. Climate change affects disease by increasing or decreasing the encounter rates between host and pathogens by changing the ranges of the two species. Disease severity-positively correlated with increased virulence of pathogens which are mediated by host resistance that is affected by climate change (Marco *et al.*, 2012). Climate change will also affect plant pest and diseases in relation to other global change phenomena- new species, new vectors, shifts in land use, expansion of tropical/temperate areas, loss of biodiversity etc. (Chakraborty *et al.*, 2005).

Elevated temperature increase winter survival of plant pathogen, accelerated vector and pathogen life cycles and hence pathogens might survive outside their historic range. Geographic expansion of pathogens influence pathogen populations reproduce sexually or asexually. Similarly, elevated CO_2 can increase leaf area, leaf thickness. Higher number of leaves, total leaves area per plant enhance photosynthesis, increase water use efficiency and infection rates (Stella *et al.*, 2012).

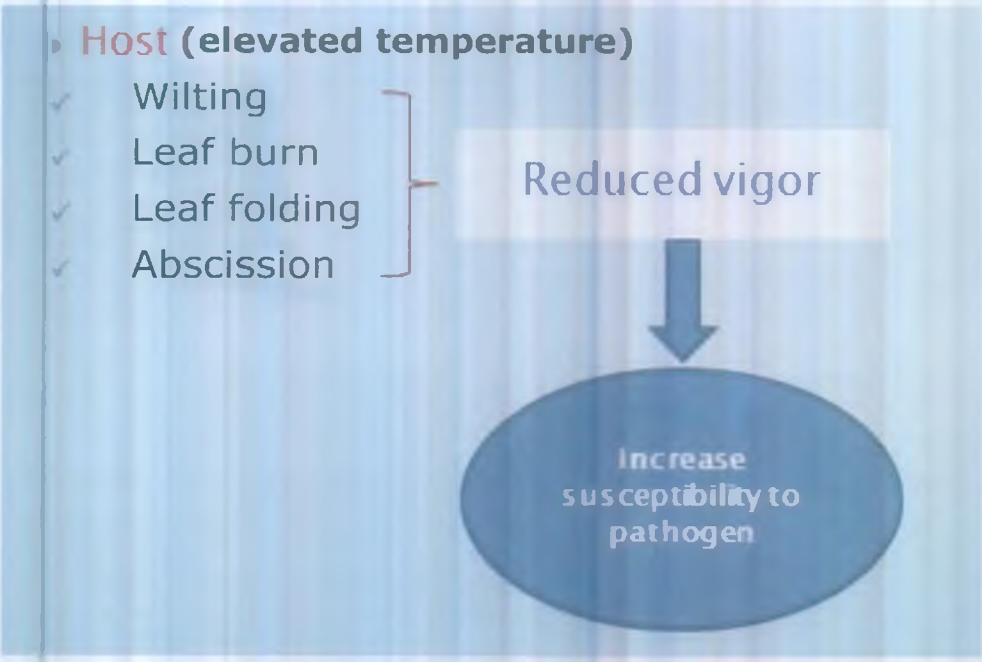


Figure 3. Impact of Temperature on the host plant

Increased frequency of heat and drought may also contribute to disease susceptibility/resistance. Drought can aggravate the effects of soil borne diseases, like Macophomina, Fusaria and others (Goto, 1992).

Table 1. Growth temperature of plant pathogenic bacteria

Bacteria	Minimum	Optimum	Maximum
Erwinia amylovora	0.5°-3.0° C	28°-30°C	≥37° C
E. carotovora sudsp. *atroseptica*	3	27	32-35
E. carotovora sudsp. *carotovora*	6	27	35-37
Pseudomonas caryophylli	5	30-33	46
P. cepacia	6-9	30	Termophylic
Ralstonia solanacearum	10	35-37	
Acidovorax avenae subsp. *avenae*	0	30-35	40
P. syringae pv. *glycinea*	2	24-26	35
P. syringae pv. *pisi*	7	27-28	37.5
Xanthomonas campestris pv. *campestris*	7-10	28-30	36
X. campestris pv. *malvacearum*	7-10	25-30	38-38
X. oryzea pv. *oryzea*	5-10	26-30	40
X. citri subsp. *citri*	10	28-30	38
Agrobacterium tumefaciens	0	25-29	36

(Masao Goto,1992)

Elevated temperature induces wilting, leaf burn, leaf folding, abscission and affect susceptibility to pathogen (Figure 3). Climate change can also lead to the emergence of pre-existing pathogens or can provide the climatic conditions required for pathogens to emerge as in the case of citrus canker in the African continent (Eshetu,2009). Under climate change, many pathogens are increased and have high pressure in the crop area that can cause much more plant diseases. The increase in CO_2 and the concentration of other Pollutants, greenhouse gases, has already resulted in an increase in the global average temperature of 0.6–0.7°C over the last century (Walther et al., 2002). This average increase has been translated in a trend in many regions towards shorter and warmer winters (Quarles, 2007). There is widespread evidence that such seasonal shifts have already affected the phenology, abundance and distribution of many species (Körner and Basler, 2010).

Climate change is just one of the many ways in which the environment can move in the long term from disease-suppressive to disease-conducive or vice versa (Baker et al., 2000). Therefore, plant diseases could be even used as indicators of climate change (Garrett, 2008), although there may be other bio-indicators which are easier to monitor.

Long-term datasets on plant disease development under changing environmental conditions are rare (Scherm, 2004) but, when available, can demonstrate the key importance of environmental change for plant health (Jeger and Pautasso, 2008).

Interactions among global change factors direct effects on plant health of climate warming, availability of high free moisture (fig.4), increased pollutants and CO_2 concentrations (Davies et al. 2011) will be accompanied by the easier introduction of exotic invasive species (Chakraborty et al.,2000).

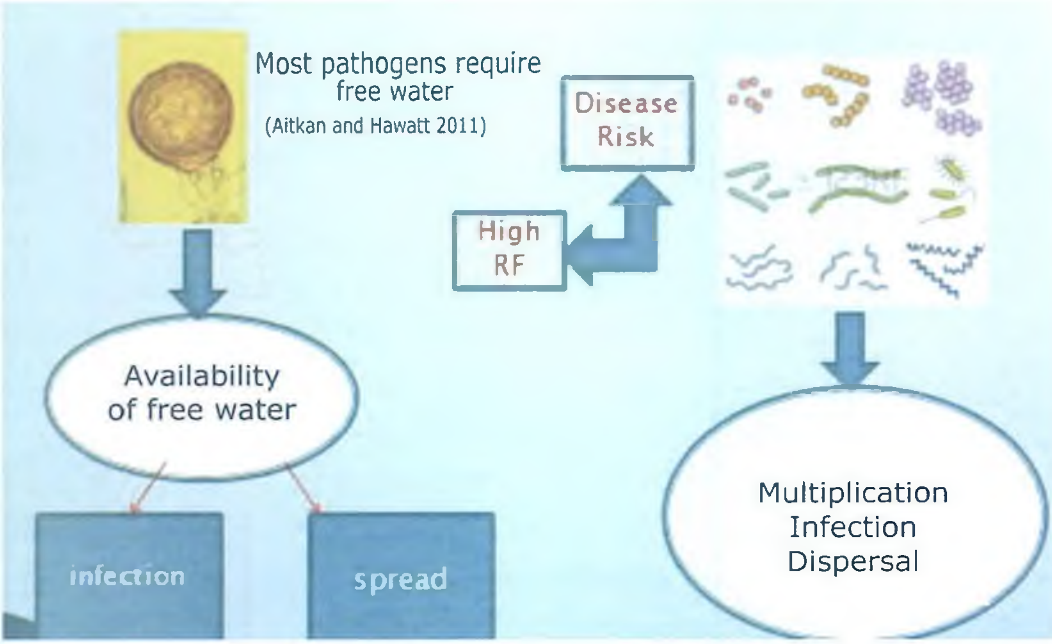


Figure 4. Impact of moisture on plant pathogens

Emerging and re-emerging plant diseases

Emerging and Re-emerging plant diseases are caused by pathogens that have increased in incidence, geographical or host range, have changed pathogenesis (Virulence) or those that have been discovered or newly recognized (Karen *et al.*, 2005). Emerging and Re-emerging plant diseases might occur as a result of Pathogen pollution, movement of pathogen outside their natural geographical or host-species range, climate change, temperature, precipitation, CO_2 concentration, changes in agriculture, Intensification, diversification and globalization (Anderson *et al.*, 2004). These incidents will also affect the reproduction, spread and severity of many plant pathogens, thus posing a threat to our food security, cases in point in Ethiopia are; Bacterial wilt of ginger (*Ralstonia solanacearum*), (Fegan and Priori, 2005), Maize Lethal Necrosis Disease (MLND) (Wangai, 2012), White rot of alliums (*Sclerotium cepivorum*) (Anonymous,2012), Yellow Crinkle and Mosaic

(*Candidatus Phytoplasma)* of papaya *and* Citrus canker (*X.axonopodis* pv.*citri*) (Eshetu, 2009).

On the other hand, there are a number of re- emerging plant diseases that gained economic importance in the country. Bacterial Blight of Coffee (BBC) (*Pseudomonas syringae* pv. *garcae*) ,wheat rusts mainly Yellow or Stripe rust (*Puccinia striiformis* (syn. *P.glumarum*)), Stem rust (*Puccinia graminis* f. sp. *Tritici)*. Similarly,there are very serious plant diseases in the other part of the world that are classified as International Bio-threats. Among these diseases the most serious ones that might affect agriculture if introduced to Ethiopia are; Ralstonia Bacterial Wilt (Blood Disease of Banana) caused by the bacterium *Ralstonia solanacearum* race 2 that has been , reported to occur in Asia and South America (Denny, 2005). Similarly, Potato black leg caused by a new bacterial pathogen, *Dickeya solani, has appeared as a major threat to* potato production in Europe and Israel (Wolf *et al*., 2014).

Apple Fire blight (*Erwinia amylovora*) which is widespread in North America , Europe, and localized in north and southern Africa and Bacterial Decline of Papaya (*Erwinia papayae)* that are known to be distributed in south, north and central America, Europe, Oceania, the Caribbean and Africa might also be considered as threats to Ethiopia.

Plant disease management strategies and tactics

Strategies are overall plans for reaching a particular objective while tactics are the specific means for implementing a given strategy. The many strategies, tactics and techniques used in plant disease management can be grouped under one or more very broad principles of action. The simplest system consists of two principles, prevention (prophylaxis in some early writings) and therapy (treatment or cure). Prevention includes disease management tactics applied before infection (i.e., the plant is protected from disease), the second principle (therapy or curative action) functions with any measure applied after the plant is infected i.e., the plant is treated for the disease (Molina, *et al.* 2014). Plant disease management strategies and tactics should be fitted in to an appropriate overall strategy and be developed based on Knowledge of pathogen's life cycle; how environmental factors impact host-pathogen interaction; available pest control tactics and their relative effectiveness. According to cooke and coworkers, 2007 there are three components of disease management strategies.

The first one is reduction of the initial plant disease inoculum, the second, reduction of the infection rate and third is reduction of duration of the epidemic. Each of these components can be further developed using traditional principles of plant diseases.

Management strategies to Emerging and re-emerging diseases

As a result of climate change, It appears that future climate change challenges will not be met by a single solution, but by a mix of different approaches adapted to different situations managing plant diseases using single management practices may not be practical. Diversity is needed as a consequence of all these potential impacts of climate change on the health of plants and their associated organisms (Nicole *et al.*, 2009). Subsequently, it appears that there is increasing recognition that we need to develop strategies to mitigate the appearance of emerging and re-emerging plant diseases and thereby increasing crop productivity and the ultimate food supply.

Conclusions and recommended future steps

On the basis of the above mentioned facts, it is plausible to infer that climate change has an influence on inducing various Emerging and Re-emerging diseases on economically important food, industrial and export agricultural crops.

Climate change effects on plant health are likely to be ubiquitous, both in terms of direct and indirect impacts. Maintaining plant health across the planet, in turn, is a key requirement for climate change mitigation, as well as the conservation of biodiversity and the provision of ecosystem services under global change. Since there are inherent limits in our understanding of plant pathosystems and their interactions with future climates, it is likely that a diversity of management strategies, including learning from our mistakes, is a better choice than a single, inflexible solution (Mitchell, *et al.*, 2005). As an exception, adding diversity to our fields, plantations, forests, and landscapes appears as a commendable insurance policy which may increase the adaptation potential of a range of managed ecosystems (Jemma *et al.*, 2010). To maintain ecosystem health and services under variable, unpredictable or unknown conditions, we need more resilient systems, decentralization, participatory research and breeding networks.

Climate change has many future initiatives required in the following areas: Increase in active global disease surveillance is required since the lack of precise knowledge of current disease incidence rates makes it difficult to comment about whether incidence is changing as a result of climatic conditions. Incidence data are needed to provide baseline information for epidemiological studies and will be useful for validating predictive models (Bosch *et al.*, 2007).

So far, there are no research activities undertaken in Ethiopia on impact of climate change on plant diseases under field conditions or disease management under climate change. However, in the other part of the world some assessments are now available for a few countries, regions, crops and particular pathogens which concern with food security (Parmesan, 2006). Now, emphasis must shift from impact assessment to developing adaptation and mitigation strategies and options. First, there is need to evaluate under climate change the efficacy of current physical, chemical and biological control tactics, including disease-resistant cultivars, and secondly, to include future climate scenarios in all research aimed at developing new tools and tactics. Disease risk analyses based on host-pathogen interactions should be performed, and research on host response and adaptation should be conducted to understand how an imminent change in the climate could affect plant diseases (Bosch *et al.*, 2007). Increased focus is needed on how a changing environment affects host-pathogen evolution, pathogen characteristics; such as frequency of generation and proportion of sexual reproduction affect the rate of adaptation, host characteristics; such as life span affects rates of adaptation of both host and pathogen populations. Research on the various aspects of this problem associated with potential climate change and plant diseases should be initiated and undertaken. At the same time, increased involvement of the many stakeholders and scientists from outside plant pathology should also be considered. Under Ethiopian context, however, the task of managing emerging, re-emerging and bio-threat disease mitigation strategies should not be left only for few institutions; rather, there should be concerted efforts among all stakeholders. Local, regional and international cooperation and collaborations are needed to better understand the impact of climate change on plant diseases and develop mitigation strategies and final solutions. The need to develop strategies with multifaceted tactics that are based on epidemiology of the pathogens in point for long-term adaptation and insurance in agriculture should be strictly emphasized.

Regarding the issue of Bio-threats, it might only be a matter of time before these diseases are introduced to the country unless and otherwise the necessary precautionary measures are taken on time. Subsequently, it is quite mandatory to create awareness to the farming community on these specific diseases and the quarantine system, both International and domestic, should be vigilant and ensure that none of these diseases are introduced in to the country.

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Alien Invasive and Emerging Resident Pests of Crops in Ethiopia

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Abstract

Invasive alien pests are non-native species that are introduced deliberately or unintentionally in areas outside their natural habitats, where they become established, proliferate and spread, causing damage to the environment. Owing to absence of pest inventory, it is difficult to differentiate recently introduced alien pest species from resident pests whose status changed to economically important due to various reasons. As a result almost all emerging pests are considered alien invasive pests. In most cases invasive alien pests and emerging pests are used as synonymous. Frequent introduction of alien invasive pests threatening agriculture has become a common phenomenon in Ethiopia similar to several countries in different parts of the world. Proceedings of the 17th annual conference of the Plant Protection Society of Ethiopia (PPSE) (Bayeh, 2012a) provides list of recently introduced disease, insect and weed pests and efforts in their management in Ethiopia. Several new pest species which resulted huge impact on the country's agriculture and economy have been recorded since the publication of the proceeding of the 17th annual conference of PPSE. Examples include the tomato leaf miner/fruit borer, Tuta absoluta, the white mango scale, Aulacaspis tubercularis, the maize lethal necrotic virus (MLNV), The Bacterial wilt of ginger, Ralstonia solanasearum. Strengthening the plant quarantine service of the country both in human and infrastructure can help to timely react to new introductions and hence help to mitigate associated impacts. It was with this objective that 20th annual conference of PPSE was devoted to deliberate on the state of affairs of plant quarantine in Ethiopia (Gashawbeza 2014). This paper outlines important insect, weeds and diseases pests introduced to Ethiopia in the past decade or so. Bio-security issues that need to be considered to face the challenges of new pest introduction are also described.

Introduction

Invasive Alien Species (IAS) are non-native species that are introduced deliberately or unintentionally in areas outside their natural habitats, where they become established, proliferate and spread, causing damage to the environment. These include plants, birds, insects, pathogens, etc. Trade, travel, transport and tourism are the main routes for accidental introduction where as their introduction for Agro forestry, pasture and biological control is regarded as intentional introduction.

Historical Global Examples

The late blight of Potato - *Phytophthora infestans introduced* into Europe from South America inadvertently in 1843-44 devastated potato cultivation in Ireland in 1845 and resulted in death of 1 million people due to famine - starvation aand a million more emigrated from Ireland shores.

The introduction of coffee rust - *Hemelia vastatrix* in Srilanka in 1875 reduced production from 400 million pounds in 1870 to 5 million pounds in 1889. Its introduction to India in 1876 affected the Coffee industry badly forcing replacement of coffee plantation by tea.

Impacts of invasion

Biological invasion has impacts on the economy of a country and its biodiversity. They affect the environment and biodiversity by suppressing and replacing natural vegetation. The invasive weeds parthenium (*Parthenium hysterophorus*), prosopis (*Prosopis juliflora)* and *Lantana camara* in Ethiopia are good examples on the impact of introduction and invasion on biodiversity of a country (Rezene *et al.* 2012). *Prosopis juliflora* was introduced intentionally for agro-forestry purpose; it is aggressively invading pastoral areas, destroying natural pasture, displacing native trees. *Parthenium hysterophorus* was introduced unintentionally with food aid, now growing out of control everywhere with great threats to local biodiversity, agricultural productivity, socio-economic and human health impacts. *Lantana camara* deliberately introduced as an ornamental shrub has been spread by birds and animals that eat its fruits but cannot digest the woody seeds (Rezene *et al.* 2012).

Invasive pests of Ethiopia

Brief description on period of introduction to Ethiopia and history of past movement of recently introduced insect, disease and plant pests are highlighted below:

Insect pests

The Greater grain borer: Its occurrence in Ethiopia was not known until 2008 (Abraham, *et al.*, 2012). Its presence in Ethiopia was confirmed in 2009 through trap catches deployed at the Moyale Ethio- Kenyan border by entomologists of Melkassa Agricultural Research Center using sing pheromones obtained from the International Center of Insect Physiology and Ecology (ICIPE). However, according to Abraham *et al.* (2012) the pest was not reported to be found in any of the grain samples obtained from different stores and market places in suspected areas in the districts of Moyale, Bulo Hora and Arsi

Negele suggesting that detecting the presence of the pest at low population is difficult (www. infonet-biovision.org).

Woolly apple aphid, *Eriosoma lanigerum* Hausmann The aphid is native to North America. It is a key pest of apple and is well spread in almost all apple growing areas of the world (Nicholas *et al.*, 2005). The aphid inhabits both the aboveground (trunks and branches) and underground parts (roots) of an apple tree. It sucks sap from aerial as well as subterranean parts of the apple tree and induces hypertrophic galls on the roots and limbs of apple trees which hinder the normal growth of the plants (Nicholas *et al.*, 2005).

The woolly apple aphid was recorded in Ethiopia nearly three decades ago on several introduced apple cultivars at Holetta research center and latter at Tseday farm, the first apple orchard in the country (Bayeh 2012b). Native to North America, it is a major pest of apple worldwide (Nicholas *et al.*, 2005).

Citrus woolly whitefly: This pest was reported for the first time in East and Central Africa in the early to mid 90s with heavy damage to citrus in several countries in the region (Lohr 1997). Its occurrence in Ethiopia was detected from leaf samples collected from orange trees planted in homesteads around Wonji and Nazareth towns in December 2000, the identity of which was confirmed by Dr. Bernhard Lohr of the International Center of Insect Physiology and Ecology (ICIPE). Its occurrence in Ethiopia however • was made public during the 11th annual conference of the Crop Protection Society of Ethiopia (Getu *et* *al.* 2003). Gashawbeza and Abiye (2012) provides information on current research efforts to manage the pest.

White mango scale: Occurrence of White Mango Scale (WMS), *Aulacaspis tubercularis* Newstead (Hemiptera: Diaspididae), in Ethiopia was known in 2010 (Mohammed *et al.* 2012a). It had remained confined to western Ethiopia where local mango trees of old age found until recently. The presence of the pest in the Central Rift Valley was known from diagnosis of the pest infested mango leaf at Melkassa Agricultural Research Center (Gashawbeza *et al.* 2015) in June 2014. The pest is Asian origin and distributed all over the world. CABI distribution map of pests show that *A. tubercularis* occurs in several countries of west Africa and African countries south of Ethiopia including east African countries, Uganda, Kenya and Tanzania (http://www.plantwise.org/KnowledgeBank/Datasheet.aspx). *A. tubercularis* injures the leaves and fruits of mango tree. Infested mango fruits have conspicuous pink blemishes around the feeding sites of the scales. In nurseries, severe early-stage infestation retards growth. Gashawbeza *et al.* (2015) provides Information on the distribution of the pest in the Central Rift valley and current efforts to manage the pest.

Tomato leaf miner: Occurrence of the tomato leaf miner, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in Ethiopia was confirmed following heavy infestation of tomato, *Solanum lycopersicum* L., in the Central Rift Valley (CRV) region of Ethiopia in February 2013 (Gashawbeza and Abiye, 2013). .The pest wiped out tomato plantations, causing 100 % crop loss for some producers. *Tuta absoluta* is a highly destructive leaf-mining and fruit-boring invasive insect pest of tomato in several countries of Latin America, Europe, Africa and Asia (Desneux *et al.* 2010). The pest is native to South America and In East Africa, the first record is from Sudan in 2010 (Mohamed *et al.* 2012b). Transportation of tomato fruit from one country to another is regarded as the major means of long-distance dissemination of *T. absoluta*. Examples of this include the introduction of the pest to Argentina from Chile in 1964 and to Spain from Latin America in 2006 (Gashawbeza 2015). Wind-assisted natural spread of the adult is also an important factor in the local distribution of *T.absoluta* (Desneux *et al.* 2010). However, this may be of secondary importance in countries with a weak quarantine organization. In such countries, the movement of infested seedlings for planting and infested fruit to market, pose major risks. The reduction in the supply of tomato fruit in the market as a result of *T.absoluta* damage to the crop could increase the chances of introducing the pest to new areas through transportation routes and tomato transportation boxes (Al Zaidi 2013). Insecticides effective for the management of the pest under Ethiopian condition include diamide insecticides such as chlorantraniliprole and spinosyns (spinetoram and spinosad) (Gashawbeza 2015).

Other alien invasive insect pest species of recent introductions include the fruit infesting fly *Bacterocera invadens* (Diptera: Tephritidae), pea weevil, Cotton mealy bug, cyperus aphid. The cactus cochineal introduced for dying purpose turned to be a major insect pest of cactus pear in the Tigray region of Northern Ethiopia.

Disease pests

Citrus Canker: Citrus canker in Ethiopia was first recorded in 2004 (Eshetu *et al.* 2005). The probable origin of the citrus Bacterial cancker is south east Asia. It had invaded the whole Asian region before it reached in Africa and subsequently distributed to other parts of the world including Oceania, South America the middle east and North America (Eshetu *et al.* 2005). Short distance transmission of the pathogen *Xanthomonas axanopodis* pv. citri is by wind, rain and human-derived materials such as contaminated cutting tools and infected plant clippings. Long-distance dissemination of the pathogen occurs primarily via the movement of infected planting and propagating material, such as bud-wood and rootstock seedlings or budded trees from nurseries. The pathogen is currently found in several areas of Ethiopia (Eshetu and Binyam 2012).

Maize lethal necrotic disease (MLND): Maize lethal necrosis disease was first reported in Kenya in the year 2011 (Adams *et al.*, 2012). In the ensuing years, it spread to other east African countries including Tanzania, Uganda, South Sudan and Rwanda, with huge damage to maize cultivation. Its presence in Ethiopia was detected in 2014. The disease is reported to be a result of combination between Maize chlorotic mottle virus (MCMV) with any cereal infecting potyviruses such as Sugarcane mosaic virus (SCMV), Maize dwarf mosaic virus (MDMV) or Wheat streak mosaic virus (WSMV) although recent work of Adams et al (2012) shows that MCMV is a threat on its own and may have a significant yield loss even in the absence of other viruses.

Depending on the area of maize cultivation, up to total crop failure due to the disease has been observed in east African countries including Ethiopia. Chlorotic mottle on the leaves (usually starting from the base of the young leaves in the whorl and extending upwards towards the leaf tips), shortened internodes, premature aging of the plants, necrosis of leaf margins, that progress to the mid-rib resulting in dying up of whole leaf, necrosis of young leaves in the whorl before expansion leading to a 'dead heart' symptom, premature drying and poor grain fill of the husks are the disease symptoms. The disease is transmitted mechanically and spread by several insect vectors including leaf hoppers, thrips aphids and cereal leaf beetles depending on the virus type (Leaf let, Bako Maize Research Center).

Other alien invasive disease pests of recent introductions include leaf and fruit spot of citrus, the wheat stem rust strains (Ug 99), Faba bean gall disease, avocado root rot and ginger bacterial wilt.

Weed pests

Detail accounts on status and management of invasive alien plant species in Ethiopia can be found from Rezene *et al.* (2012). Among over 35 invasive alien plants which are of great concern to Ethiopia, *Prosopis juliflora, Parthenium hysterophorus* and water hyacinth (*Eichhorina crassipes*) are ranked top as they are threatening biodiversity by displacing native species causing reduction of biodiversity of native flora and fauna (Rezene 2008, Taye *et al.* 2009).

Distribution status of important invasive alien species in Ethiopia and affected ecosystems are presented in Table 1.

Table 1. Top 20 Invasive Alien Plants in Ethiopia (adapted from Rezene *et al.* 2012)

Species	Ecosystems highly affected*	Distribution status
Parthenium hysterophorus	1,2,3,4,5,6,7,8	High
Prosopis juliflora	1,2,3,4,5,6,7,8	Moderate
Opuntia ficus-indica	3,4,5,6	Moderate
O. stricta	3,4,5,6	Moderate
Mimosa diplotricha	1,2,3,4,5,6,8	Moderate
M. pigra	3,4,7	Low
Cryptostegia grandiflora	2,3,4,7,8	Low
Lantana camara	1,2,3,4,5,6,8	High
Acacia drepanolobium	1,3,4	Moderate
A. saligna	2,3,4,5	Low
Parkinsonia aculeate	2,4,5,6	Low
Nicotiana glauca	1,2,3,4,5,6	Moderate
A. ochroleuca	1,2,3,4,5,6	High
Xanthium strumarium	1,2,3,4,5,6	High
Xanthium spinosu	1,2,3,4,5,6	Moderate
Psidium guajava	8	Low
Senna didymobtrya	1,2,3,4,5,6,8	High
Calotropis procera	1,2,3,4,5,6,7,8	Moderate
Ricinus communis	2,4,5,6	Moderate
S. occidental is	2,4,5	Moderate

* 1 = Cultivated land, 2 = Roadside 3 =Grazing areas 4 - Non-cultivated land 5 = Rural villages6 = urban areas 7 = Riverside 8 = Forest areas S

Plant Quarantine in Ethiopia

Proceeddings of the 20th annual conference of PPSE gives a brief account on the state of affairs of Plant quarantine in Ethiopia (Gashawbeza 2014). Plant Quarantine (PQ) refers to all activities designed to prevent the introduction and/or spread of quarantine pests or to ensure their official control. Prevention and Eradication is performed based on Pest Risk Analysis (PRA) which is the process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it. The question is - do we conduct a meaningful PRA in Ethiopia?. From PRA definition to determine 'an organism is a pest, whether it should be regulated' requires efficient diagnosis, pest list, etc . The plant quarantine regulation no. 4/1992 of Ethiopia empowers the Ministry of Agriculture to take Phytosanitary measures to prevent the introduction and/or spread of quarantine pests or to limit the economic impact of regulated non quarantine pests. This regulation is unrevised and the measure seems limited to issuance of import permit. The approach to managing the risk of incursions of exotic pests and diseases is multi-layered, involving complementary measures applied along the biosecurity continuum—at pre-border, border and Post border points. Pre-border activities seek to prevent biosecurity risks reaching a country's border which requires import risk analyses. Border activities seek to intercept bio-security risks that are present at airport, sea port, mail centers, borders entry points through import permit decisions, Inspection of passengers and their luggage and post-arrival quarantine. Post-border arrangements are designed to prevent establishment of the pest in the country. Plant quarantine service in Ethiopia started in the early 1970s following issuance of Plant protection decree no 56/1971. Plant quarantine regulation number 4/1992 provides terms to control pest movement with import and export plant commodities. Inspection and certification are conducted to provide plant quarantine service by stations distributed in the different areas of the country. Currently theses stations are located at Bole international air port (Addis Ababa), Adama, Moyale, Dire Dawa, Metema. In addition to these stations liaison offices to the regional agricultural Bureau are found in Bahar Dar, Mekele, Mehoni and Kombolcha (Teklu 2014). Poor enforcement of plant quarantine regulations, Porous international borders, Unregulated import and movement of planting materials and agricultural products, and poor staffed, equipped and coordinated national and local quarantine systems are some of the major reasons for frequent invasion and damage by invasive alien species in Ethiopia similar to several less developed countries.

Emerging pests

Maize streak virus and gray leaf spot diseases on maize, coffee wilt diseases on coffee, tomato yellow leaf curl virus and nematode on tomato, wilt diseases on pepper, root rot on Alliums, common bacterial blight on haricot bean, aschochyta blight on faba bean, bacterial blight on haricot bean and phyllody diseases on sesame are examples of emerging disease of crops in Ethiopia. Examples of emerging insect pests of crops include sesame seed bug on sesame and termites on ground nut. The plant species *Senna didemobotrya*, water hyacinth, *Argemone ochraleuca*, Opuntia *Ficus indica* and *Calotropis procera* are some of the emerging weeds in Ethiopia (Rezene *et al.* 2012). Abraham (2009 a) and (2009b) provides information on the status and management of many of the examples listed here.

Management of alien invasive and emerging resident pests

Figure 1 shows the management approach to be followed before, during and after introduction of an invasive alien species (IAS). Preventing the introduction of a new pest through strict legislation or quarantine is the first stage in the management of IAS. Periodical monitoring and surveillance need to be made to detect presence of an invasive species. This early detection programs help to determine whether a pest is established in an area or not. If the IAS is not established, eradication may be feasible. Periodic survey needs to be conducted to confirm that the invasion is checked. If the IAS gets established in an area, eradication may not be feasible and hence different management methods including mechanical, biological and chemical be developed to check the invasion. Failure to develop and implement management methods against established IAS will lead to invasion threat and emergency operation. Bayeh (2012a) provides information on management options for some of recently established IAS in Ethiopia. Abraham (2009 a and b) provides further information on some of the IAS and reemerging established pests of Ethiopia.

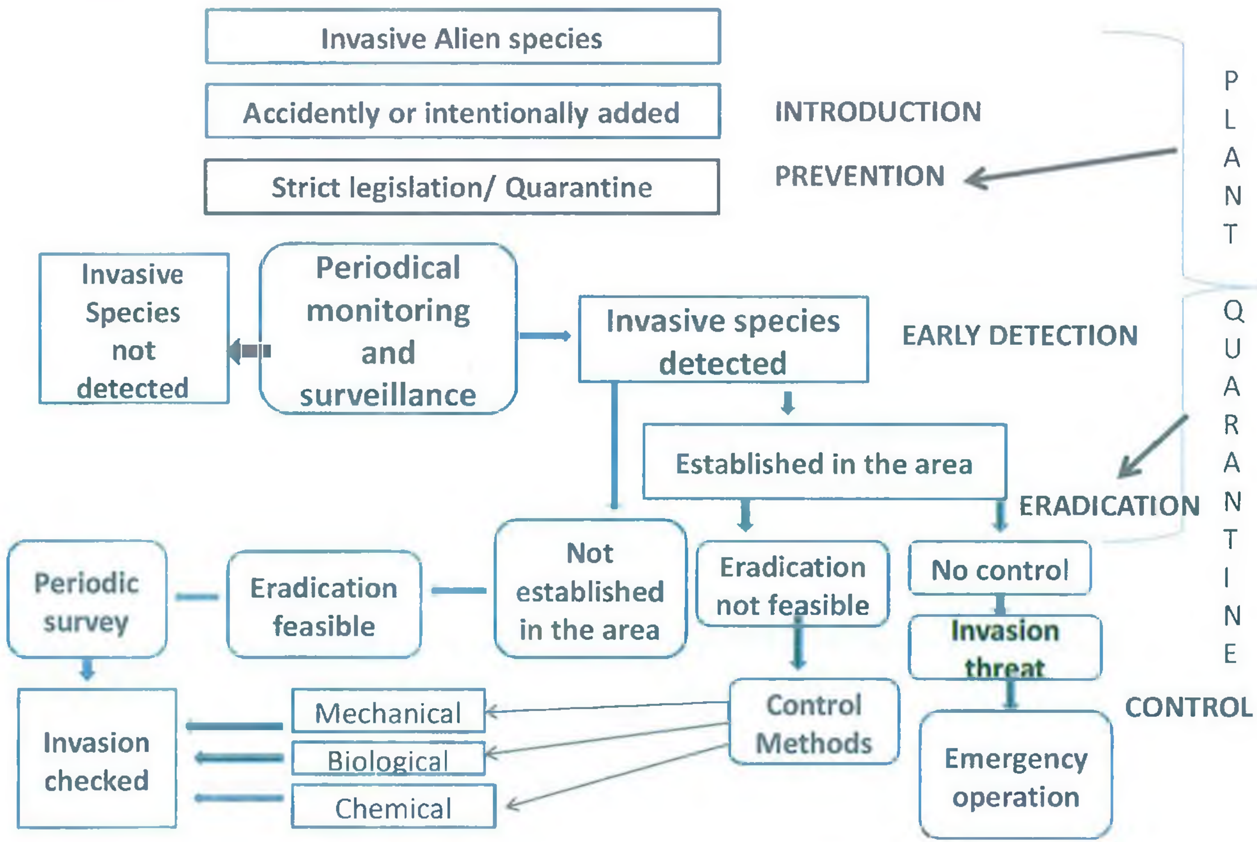

Figure1. Management Strategy against alien invasive pests

What needs to be done

I. Invasive Alien species

- Strengthen the national capacity for a meaningful PRA at different levels in import and export commodities
- Establishing a strong national reference bio- systematic center
- Strengthening the plant health clinic and quarantine stations with human and material resources
- Establishing a pest advisory group at national level for pest list development, pest monitoring and rapid response
- Revising the plant protection policies and regulations

II. Emerging Resident Pests

- Periodic monitoring to establish status for rapid action
- Evaluation and adjustment of the current pest management practices /recommendations
- Studies on the relationship of unusual weather with pest population

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The Contribution of Mycotoxin to the Current Food Safety Concern of the World

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Introduction

A number of scientists defined mycotoxins in a number of publications. However, the definition which most literatures share is "Mycotoxins are **toxic secondary metabolites of fungi** and are **common contaminants of food** and **feed commodities** worldwide". A number of fungi produce mycotoxin, but the common ones are fungi from the genera *Aspergillus, Fusarium* and *Penicillum.* Mycotoxin studies are relatively a new science which is progressing at the fastest rate mainly due to the growing concern of food safety. Over 400 mycotoxins are known today, but the most important ones as far as human and animal health concerned are Aflatoxin (B1, B2, G1 and G2), fumonisins (B1, B2, B3), ochratoxin A, zearalenone and the trichothecenes.The trichothecenes form a group of chemically related Fusarium mycotoxins which include deoxynivalenol, 3-acetyl and 15-acetyldeoxynivalenol from F. graminearum, T-2 toxin and HT-2 from *F. sporotrichioides,* nivalenol from *F. kyushuense* and Diacetoxyscirpenol from *F. scirpi.*

Factors enhancing mycotoxin production

Though different fungal species respond variably to environmental factors, the combination of insufficient drying of substrates and humid atmospheric conditions results in unacceptable levels of mycotoxin in food and feeds. The most important thing in the process of mycotoxin production is the availability of water for growth of the producing fungus. Temperature, however, is an important factor as well.

In grain storage, the factors of water activity, substrate aeration and temperature, inoculum concentrations, microbial interactions, mechanical damage, and insect infestation can play a role in mycotoxin contamination.

Effects of mycotoxin on human and animal health

Exposure to mycotoxins can produce both acute and chronic toxicities ranging from death to deleterious effects on the central nervous, cardiovascular, pulmonary and digestive systems. Mycotoxins may also be carcinogenic, mutagenic and immunosuppressive, stunting to children and hinders trade and affect economy. For example in all animals, aflatoxin can cause liver damage, decreased reproductive performance, reduced milk or egg production, embryonic death, teratogenicity (birth defects), tumors and suppressed immune system function, even when low levels are consumed.

Mycotoxins exert toxic effects on animals and humans health which is referred to as animal and human **mycotoxicosis.**

Human exposure to mycotoxin occurs through the consumption of food that has been contaminated by toxigenic fungi before harvest or during storage and through inhalation of air born mycotoxins produced by indoor fungi (under storage condition).

Animals such as dairy cattle feeds on oilseed cake, cereal bran's, silage and hays are reported to be contaminated with mycotoxins.

Distribution of mycotoxin in the world

All countries are affected by mycotoxin. For example USA had about 900 Million USD costs at one time. However, Tropical countries especially sub-Saharan African countries are more affected by mycotoxin. In 2008 about 43345 deaths due to liver cancer which is 10.3% of the total mortality due to cancer were reported from sub-Saharan African countries. In 2004 in Kenya 125 deaths due to mycotoxin reported. Though all crops can be affected by mycotoxin crops like ground nut, maize, sorghum, millet and cotton seed meal were reported to be susceptible.

Threshold for mycotoxin

It is next to impossible to get mycotoxin free food. Most of the mycotoxins are also toxic at certain level of concentration. As a result of the health hazard of mycotoxin, the need for setting maximum levels of mycotoxin in foods and feeds is crucial. Currently, the occurrence of aflatoxin M1 and M2 in milk is reported to be considered as high health hazard and most countries have standardized tolerance level for aflatoxin M1 in milk and milk products and meat as shown in Table 1.

Table 1. Maximum limits for aflatoxin M1 in milk

Country	Mg/Kg or Mlt/lt	Food
Sweden	0.05	Liquid milk products
Australia	0.05	Milk
Germany	0.05	Milk
Netherlands	0.02	butter
Switzerland's	0.05	Milk
Belgium	0.05	Milk and milk products
USA	0.50	Milk

Source:

Maximum limits for Ochratoxin A (OTA)

Ochratoxin A (OTA), a toxin produced by a few species of fungi in the genera *Aspergillus* in coffee that is not properly dried or stored after harvest is a key quality factor to be considered in coffee market. The EU Commission set maximum permissible levels of OTA in roasted coffee beans and ground roasted coffee to be 5.0 µg/kg and in soluble coffee (instant coffee) to be 10.0 µg/kg.

Different countries have also set maximum permissible levels of OTA in green coffee beans; Czech Republic 10 ppb, Finland 5 ppb, Greece 20 ppb, Hungary 15 ppb, Italy 8 ppb, Portugal 8 ppb, Spain 8 ppb, Switzerland 5 ppb.

Codex General Standard for Contaminant and Toxins in Food and Feed (Codex Stan 1993-1995)

Total Aflatoxins, maximum limit for Almonds, Brazil nuts, Dried fig, Hazelnut, peanut, Pistachios (**further processing**): 15µg/kg
Almonds, Brazil nuts, Hazelnut, Pistachios (**ready to eat**): 10 µg/Kg

Aflatoxin: 0.5 µg/Kg

Status of mycotoxin in Ethiopia

In Ethiopia, serious health hazards due to mycotoxins comes as a result of forced consumption of mycotoxin contaminated grains both by human and animals. Plates 1 & 2 demonstrated the severity of mold growth in sorghum immediately after harvest (plate 1) and on sorghum grains stored in under ground pit (plate2) which is a common storage method in major sorghum growing areas of Ethiopia such as Eastern Ethiopia, north eastern Ethiopia, southern Ethiopia and Tigray region. Plate 3 indicates the wrong attempts farmers did to protect grains stored in underground pit from mold infection by covering it with insecticide impregnated nets which may toxic when consumed.

Plate 1. Sorghum head harvested under humid condition and heavily molded.

Plate 2. Sorghum grain stored in the underground pit.

Plate 3. Sorghum grain stored in the underground pit covered with insecticide impregnated mosquito net

Research status of mycotoxin in Ethiopia

About 52% and 46% of Shewa and Hararghe farmers, respectively feed the deteriorated grain to animals whereas 37% and 42% of them, respectively consume the spoiled grains by themselves (Habtamu and Kelbesa, 2001). The crops surveyed were Barley, wheat, pepper, broad beans, maize, sorghum, peanut, millet, dry peas and tef. Over 30% of the samples contained Aflatoxin B1 and the rest 6% contained Aflatoxin G1 and stressed the health concern due to Aflatoxin and called for serious Aflatoxin Management.

Alemayehu Chala *et al.* (2014) recorded 84 and 62 metabolites on sorghum and millet, respectively and the concentration of B1 and G1 were above EU standard.

Amare Ayalew for his PhD work on sorghum mycotoxin (mostly survey).

Mycotoxin Survey of Sorghum in major sorghum producing districts of Ethiopia (FAO/WHO/AAU) was conducted by Emana and Nugussie (unpublished data) further confirmed that mycotoxin is economically important on stored sorghum grain.

Post- graduate activities are under way at Addis Ababa University in the centre for food and nutrition and Zoological sciences department which include:

- M.Sc research on hot pepper
- M.Sc research on coffee
- M.Sc Research on peanut oil
- PhD research on maize

- PhD research on coffee

Mycotoxin Management

Mycotoxins cannot be eliminated from food or feed supplies; however, their levels can be substantially reduced using good agricultural and management practices. Control measures can occur at several stages, pre-harvest (agronomic practices in the field), harvest and post-harvest. Good agricultural practices during pre-harvest and post-harvest minimizes the problem of contamination by mycotoxins. These include appropriate drying techniques, maintaining proper storage and taking care not to expose grains or oil seeds to moisture during transport and marketing. Methods for reducing levels of mycotoxins in foods or feed include physical means of separation, physical methods of detoxification, biological methods of inactivation, chemical methods of inactivation, and decreasing the bioavailability of mycotoxins to the host animal.

Physical means of separation include mechanical separation whereby contaminated particles of the substrate are removed. Physical methods of detoxification such as thermal inactivation has been used for mycotoxin, but almost all mycotoxins are quite heat stable and limited success has been achieved. Irradiation with either gamma rays, microwaves, or ultraviolet light have been used, primarily with aflatoxins, and generally have decreased the concentrations in the substrates tested. Biological methods of inactivation have been applied to field plots whereby nontoxigenic strains of the organism function as a bio-control organism. A strain of *Eubacterium* has been used with considerable success in deactivating trichothecenes by biotransformation of the epoxide group of the molecule to a less toxic molecule. Chemical methods of detoxification are most noted with the aflatoxins being degraded by ammoniation. Treatment of aflatoxins B1, G1, M1, and aflatoxicol with sodium bisulfite makes water soluble products, thereby decreasing or eliminating the toxicity of these aflatoxins. Ozonization has been used in degrading aflatoxins.

It also is efficacious in decreasing DON and moniliformin. It also has been used in vitro to detoxify and degrade cyclopiazonic acid, ochratoxin A, patulin, secalonic acid D, and zearalenone.

Probably the most interesting in controlling the effects of mycotoxins in animals has been in the development of binders of mycotoxins to render them unavailable for absorption by the host animal. Calcium aluminosilicates seem to be effective in binding the aflatoxins, thereby decreasing or eliminating toxicity to study animals.

Implementation of code of practices is another important mycotoxin management method. There are a number of mycotoxin related code of practices which include:

- Code of practice for the prevention and reduction of Aflatoxin Contamination in Peanuts (CAC/RCP 55-2004)
- Code of practice for the prevention and reduction of Aflatoxin in Tree Nuts (CAC/RCP 59-2005)
- Code of practice for the reduction of Aflatoxin B1 in raw materials and supplemental feeding staff for milk producing animals (CAC/RCP 45-1997)
- Code of practice for the prevention and reduction of Aflatoxin contamination in Dried Figs (CAC/RCP 65-2008)

General Remark about Mycotoxin

Alternatively, contaminated grains are sometimes diverted into animal feed. Giving contaminated feeds to susceptible animals can lead to reduced growth rates, illness and death. Moreover, animals consuming mycotoxin-contaminated feeds can produce meat and milk that contain toxic residues and biotransformation products. Court actions between grain farmers, livestock owners and feed companies can involve considerable amounts of money. The ability to diagnose and verify mycotoxicoses is an important forensic aspect of the mycotoxin problem. Nevertheless, many mycotoxins survive processing into flours and meals. When mold-damaged materials are processed into foods and feeds, they may not be detectable without special assay equipment. It is important to have policies in place that ensure that such hidden mycotoxins do not pose a significant hazard to human and animal health. Considerable research has been devoted to develop analytical methods for identifying and quantifying mycotoxin.

Mycotoxins occur, with varying severity, in agricultural products all around the world. Mycotoxins can enter the food chain in the field, during storage, or at later points. Mycotoxin problems are exacerbated whenever shipping, handling and storage practices are conducive to mold growth. The end result is that mycotoxins are commonly found in foods. The economic consequences of mycotoxin contamination are profound. Feedstuffs with large amounts of mycotoxins often have to be destroyed.

The chemical diversity of mycotoxins and the equally diverse substrates in which they occur pose challenges for analytical chemistry. Each group of compounds and each substrate have different chemical and physical properties, so the methods for the separation of toxins from substrates must be developed on a case-by-case basis. Since it is normally impracticable to prevent the formation of mycotoxins, the food industry has to establish internal monitoring methods. Similarly, several national and international organizations and agencies have special committees and commissions that set recommended guidelines, develop standardized assay protocols and maintain up-to-date information on regulatory statutes. There are also several mycotoxin associations government regulatory agencies survey for the occurrence of mycotoxins in foods and feeds and establish regulatory limits. Guidelines for establishing these limits are based on epidemiological data and extrapolations from animal models, taking into account the inherent uncertainties associated with both types of analysis. Therefore, there is a need for worldwide harmonization of mycotoxin regulations. Estimations of an appropriate safe dose are usually stated as a tolerable daily intake.

Remark for Ethiopia on mycotoxin

Research on mycotoxin management on major crops should be focused (Ethiopia has serious problem of mycotoxin with very little activities)

Mechanisms by which funding organization such as African Union become part and parcel of mycotoxin research in Ethiopia need to be discussed at higher level.

There should be locally organized body who can give guidance for mycotoxin activities in the country (Ethiopia was not part of PACA pilot study site because of lack such body in the country).

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A Highlight on the Health Hazard of Pesticide Applications in Ethiopia

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Abstract

Pesticides are widely defined as mainly chemicals manufactured from different compounds that are used to control agricultural pests. The most commonly used synthetic organic pesticides are grouped into organochlorines (chlorinated\ hydrocarbons), organophosphates (OP) and carbamates based on their chemical structures. Agricultural workers associated with the different stages of pesticide formulations and spraying ought to be protected to avoid unwanted contact to the chemicals. Personal Protective Equipment (PPE) is used to avoid the entry of chemical pesticides into the body. Since 1995 we are engaged in research work focusing on the hazard of chemical pesticide applications to human health in many agricultural farms in Ethiopia. The emphasis is on knowledge, attitude and practice (KAP) of farm workers and associated health hazards to the workers. In this paper some background information and a high light on some of our research results are presented.

Background

Chemical Pesticides

Pesticides are widely defined as mainly chemicals manufactured from different compounds and are used to control agricultural pests. A pesticide is any substance or mixture of substances used for preventing, destroying, repelling, or mitigating any pest (Rosenberg and O'Malley, 1997; Osorio, 2002).

Chemical pesticides are broadly categorized as **organic** and **inorganic** in which the former constitutes 97% of current pesticides (Stilling, 1992). The most commonly used synthetic organic pesticides are grouped into organochlorines (chlorinated\ hydrocarbons), organophosphates (OP) and carbamates based on their chemical structure (Bolen and Robinson, 1999). Organophosphates are derivatives of phosphoric acid and are related to the nerve gases. Since most organophosphates are less persistent in the environment and so are replacing the organochlorines. Carbamates are derived from carbamic acid. Carbamates are frequently employed to control insects that, for some reason, do not readily respond to organophosphates. Nevertheless, Chlorinated hydrocarbons and organophosphates are the pesticides that cause the greatest concern, and are used in greatest quantity around the world (Hassal, 1990).

Many developed nation have realized that long term use of such chemicals is hazardous to life and the environment and nowadays the slogan is avoiding pesticide application and producing agricultural products that are free from use of chemical pesticides that are purely organic. Organic farming is drawing attention in the developed world although they are still the major users of chemical pesticides in agriculture.

Application of pesticides

Pesticides are applied at the developmental stages of the particular crop or vegetable that is prone to be attacked by pests. Pesticides are formulated based on a given proportion of the major product with water or other appropriate solvents and then poured into containers and sprayed either by hand operated machines or on tractor loaded appliances.

Agricultural workers associated with the different stages of pesticide formulations and spraying ought to be protected to avoid contact to the chemical. As described by Kishi and Ladou (2001) washing facilities for workers were rarely located close to agricultural fields and dermal absorption continued until they can get home to wash. Therefore, working with caution is very important. Occupational health and safety standards have to be followed.

Personal Protective Equipment (PPE)

PPE are used to avoid the entry of chemical pesticides into the body. The routes of entrance are the skin, eyes, through inhalation and through eating and drinking (ingestion). The basic PPE that should be worn by pesticide applicators are head cover (helmet or cloth cap), overcoat or one-piece work suit, goggles or face shield, hand gloves (rubber or plastic), boots and rubber or plastic apron.

Associated Hazardous

Humans and other organisms

According to how their toxin works, pesticides can also be grouped as sterilants, neurotoxins, contact poisons and systemic poisons (Bush, 1997).

Acute toxicity normally occurs shortly after contact with a single dose of poison. However, the magnitude of the effect depends on the innate toxicity of the substance and its method of application. It often results from the disruption of biochemical or physiological system ranging from the molecular to the level of the organisms, and triggers a wide variety of reactions (Hassal, 1990; Garry *et al.*, 1994).
Chronic toxicity occurs when an organism is exposed to repeated small and non-lethal doses of potentially harmful substances. Responses to various chemicals include lung cancer, brain damage and necrosis of the liver and kidneys (Hassal, 1990; Garry *et al.*, 1994) it also includes birth defects.

The 50 percent lethal dose (LD_{50}) is the amount of poison that kills half the organisms in a randomly selected species. It is usually expressed in terms of milligrams poison per kilogram body weight of the experimental animals. While the LC_{50} is the lethal concentration, usually in air or water that causes 50 percent mortality of organisms (Hassal, 1990; Stilling, 1992; Rosenberg and O'Malley, 1997).

Organochlorine pesticides affect the transmission of nerve impulse by altering the concentration of Na^+ and K^+ in nerve cells and causing spontaneous twitching of muscles. This group of pesticides is toxic to the animal kingdom in general, including birds, mammals, fish as well as insects (Stilling, 1992).

Organophosphates (OP) poisoning has been associated with chronic neurobehavioral dysfunction, but no epidemiological data exist with regard to long-term consequences from carbamate poisoning

(Wesseling *et al.*, 2002). OPs are used as common poisons for suicide attempts especially among women and teenage girls in developing countries. Since they are widely available to the public approximately one-third of pesticide poisoning is caused by OP (Bishop *et al.*, 1996; Dong and Simon, 2001; Abiye Alemu and Williamson 2002; Miranda *et al.*, 2002; Penagos, 2002).

Carbamates and organophosphates exert their effects both on the insects and on mammals, including human beings, by inhibiting acetylcholinesterase at nerve endings (Stilling, 1992; Rosenberg and O'Malley, 1997). Carbamates initially react with acetylcholinesterase in the same fashion as OP and resulting in accumulation of acetylcholine (Beaumont and Buffin, 2002). However, OP inhibition is achieved by forming a chemical bond with the enzyme acetylcholinesterase in which the phosphate group is attracted to the esteric site of the enzyme and became phosphorylating. While inhibition by carbamates could take place by physical blockage of active sites on the enzyme, therefore carbamylation is easily and rapidly reversed compare with that of phosphorylation (Hassal, 1990). Carbamates have lower oral and dermal toxicity and hence are more popular (Stilling, 1992).

The toxicity of pesticides varies according to their chemical structure, purity and formulation and because of their biochemistry; different species and varieties of insects vary in their susceptibility to some pesticides.

Environment: Air, Soil and Water

Chemicals sprayed to combat agricultural pests reach the air, the soil and the ground water. Environmental impacts of pesticides are diverse and could affect the ecosystem by reducing biological diversity, interrupting food chains, modifying energy transfer, reducing the quality of soil, water and air. Some groups of pesticides such as DDT could not breakdown rapidly by microbes and persist for a long time in the environment and build up their concentration along the food chain and result in lethal doses for top predators (Buffin, 2002).

Consistent use of pesticides can lead to insect resistance, which encourages farmers to overuse pesticide products. Insecticides often killed honeybees, as a result the honey industry, the pollination of fruits and vegetables as well as uncultivated vegetation is highly affected. Long-term accumulations have indirect consequences affect agricultural development in one way or another.

The environment extends beyond a given territory of a nation, it cannot be restricted to only a given country but affects geographical regions and eventually any environmental hazard have an impact on the global environment. In my opinion, the issue of safe environment should be an issue for a global concern.

Experience of pesticide use in Ethiopian agricultural farms

Since 1995 research work focusing on chemical pesticide use in Ethiopian agricultural farms has been actively going on. The emphasis was on knowledge, attitude and practice (KAP) of farm workers and associated health hazards to agricultural workers.

The Table below shows examples of the agriculture farms where some of the studies were done and the major findings of the research work. Most of the research work was done by Kibruyesfa Lakew and Yalemtsehay Mekonnen (1998), Yalemtsehay Mekonnen and Tadesse Agonafir (2002), Michael Biru (2002), Yalemtsehay Mekonnen and Desalegn Ejigu (2004, 2005).

Farm	Title	Main Result	Study Period	Published
Birr &Ayehu (West Gojjam)	Plasma Cholinesterase level	Cholinesterase level lower in sprayers	2005	Occup Med 2005, 55: 504-505
Birr & Ayehu (West Gojjam)	Pesticide use on agric fields & health problems	Chronic respiratory problem (cough, wheezing), ALP high in Birr	2004	East Afr. Med J 2004, 82:427-432
Upper Awash(Awara Melka, Nura Era, Tibila, Zewai)	Knowledge, Attitude and Practice of pesticide use	Careful work 93%, PPD 7%, Medical check up 3%	1998-2000	Occup Med. 2002, 52: 311-315
Northern Omo State Farm	Health Status of Northern Omo Farm workers exposed to Chlorpyrifos & Profenifos	Cholinesterase levels lower after pesticide spraying	1995	Ethiop Med J. 1998, 36: 175-184

Conclusion

In Ethiopia, agricultural production has been challenged by pest infestations affecting yield and the worst scenario being destruction of seasonal harvest. In addition to this, plant material movement facilitates the accidental introduction of arthropod pests, both native and exotic, and become major constraints to agricultural production and productivity (Abate, 2002). Women's role in agricultural production places them at significantly higher levels of exposure than men. They are engaged in different types of agricultural labor activities. They work in the fields after pesticides have been applied. Women and children are also exposed to pesticide poisoning in the household. Therefore, both women and men and the community at large need to be sensitised of the hazardous consequences of pesticide applications to their health and the environment. Environmentally friendly alternatives to control pests should be introduced and promoted. Researchers and practitioners need to engage in such alternatives. Indigenous knowledge should be given attention and the potential ought to be exploited.

Recommendations

- The Agricultural sector of the country has to take serious consideration of how to safely use chemical pesticides to control pests. Formulation plant established in Ethiopia has to follow international standard of safe production of chemical pesticides taking into consideration all aspects; the factory physical set up, protection of workers, handling, storage and other related issues (e.g. Adami Tulu)
- Give training on basic principles of occupational health and safety and have discussion groups of the workers themselves so that they share their experiences and improve on their KAP.
- Regular medical checkup so that the workers can be moved to other categories of jobs with less exposure to chemicals.
- Import of chemicals has to be closely regulated; purchase in local markets has to be given to those handlers with the knowhow of safe use and handling of pesticides. They have to be given training and certification.

- Minimize the use of chemical pesticides to the extent of total prohibition of chemical pesticides has to be initiated without further delay.
- Encourage those who promote organic farming (a good example is coffee organic farming in SW Ethiopia).
- The media could play a good role in disseminating programmes of awareness creation, and sensitization of the public at large.
- Indigenous knowledge in agricultural practices has to be given importance and attention.
- Environmentally friendly alternatives to control pests should be practiced and promoted.
- A strong sustained link between farmers, agricultural workers, managers of farms, researchers from the academia will have an impact
- Need to explore experience sharing with neighbouring countries and learn from best practices of others.
- A concerted effort of government organizations, NGOs, professional associations, communities and dedicated individuals.

Specific to Agriculture workers:

1. Use PPE all the time with pesticide related work
2. Always check the label on pesticide containers so as to know what precautions you ought or have to take
3. Take shower/ wash properly after work; keep your personal hygiene
4. Keep your food and drinking area away from pesticides
5. During pesticide preparation for spraying take care to avoid spilling
6. If you encounter spilling over take the correct measure, clean immediately

7. Take extra care for all activities you are engaged in pesticide related work
8. Regular medical check up
9. Discuss with your workmates or even your community members/neighbors your experience of working with pesticides and the precaution to be taken
10. Be an agent of change by teaching your family members of what the use and harmful effect of pesticides

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Discussion of the Plenary Sessions

Chair Person: Dr. Ferdu Azerefegne, Hawassa University,
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Rapporteur: Mr Tariku Hunduma, Ambo PPRC

During the plenary session six papers were presented: The first paper was presented by Dr. Bayeh Mulatu (PhD) from FAO-Ethiopia Regional Office, an IPM expert, E-mail: bayeh65@gmail.com, Addis Ababa Ethiopia, on Pest Management Support Service System of Ethiopia: Past, Present and Future. Dr Bayeh discussed on food crop losses due to pests and diseases, history of establishment of pest management support service in the world and Ethiopia, the challenges, gaps, and future recommendation to reinvigorate the system.

The second paper was presented by *Eshetu Derso (PhD)*, Ethiopian Institute of Agricultural Research, Crop Research Directorate, Deputy Director, Email: eshetudrs4@gmail.com EIAR, P.O.Box 2003 Addis Ababa, Ethiopia; on potential influence of climate change on emerging and re-emerging plant diseases and their management strategies. Dr Eshetu on his presentation mainly focused on the influence of climate change on plant diseases and discusses different aspects related to the potential impacts of climate change on the emergence and re-emergence of plant diseases and the need to develop strategies with multifaceted tactics that are based on epidemiology of the pathogens in point for long-term adaptation and insurance in agriculture.

The third paper was presented by Dr Gashawbeza Ayalew, senior entomologist, Ethiopian Institute of Agricultural Research, Melkasa Agricultural Research center, on Alien Invasive and Emerging

Resident Pests of Crops in Ethiopia. Dr Gashawbeza in his paper outlined important insect, weeds and diseases pests introduced to Ethiopia in the past decade or so. Bio-security issues that need to be considered to face the challenges of new pest introduction were also described.

The fourth paper was presented by Dr Ayele Badebo, Senior Plant Pathologist from CIMMYT, Ethiopia on Current Status of Yellow and Stem Rust diseases of wheat in Ethiopia. In his presentation, the current status of wheat rusts in Ethiopia was described and the key drivers behind these recent rust epidemics were examined. Existing surveillance, early warning, and control measures were highlighted along with recommendations to enhance the future control of wheat rusts in Ethiopia. He has emphasized the importance of Ethiopia and the broader East African region for wheat rust evolution, long-term effective control of wheat rusts in the region was considered to be a high priority.

The fifth paper was presented by Dr Emana Getu, Associate Professor and Senior Researcher, Addis Ababa University, College of Natural Sciences, Department of Zoological Sciences, Insect Science Stream, e-mail egetudegaga@yahoo.com, P.O.Box 30526. The topic was on The Role of Mycotoxin in Worldwide Food Safety. In his paper available information on mycotoxin worldwide were reviewed and road map for the future was developed. Moreover, the Ethiopian experience was evaluated.

The sixth paper was presented by Professor Yalemtsehay Mekonnen. Professor of Cell & Human Physiology, College of Natural Sciences, Addis Ababa University, Addis Ababa. Email:

yalemtmek55@gmail.com. The paper was gave us a high light on the Health Hazard of Pesticide Applications in Ethiopia. In here presentation she touched the research work focusing on the hazard of chemical pesticide applications to human health in many agricultural farms in Ethiopia, by the emphasis on knowledge, attitude and practice (KAP) of farm workers and associated health hazards to the workers and presented some background information and a high lights on some of research results of pesticide associated health hazards.

Discussion

Ato Rezene Fessehaye

Some of the important issues rose in the plenary and the first session should be forwarded to concerned authorities in a form of resolutions for follow up actions. In addition to preparation of pest list as indicated by all presenters, we need also to categorize the importance of the existing pests particularly the plant invaders with conflict of interest. (*Prosophis juliflora, Acacia saligna*) which are being promoted for utilization by some research institutions and universities. There is a need to update the National Plant Protection Research strategy, previously prepared by EIAR. This updating should consider both the technical and organizational aspects of the plant protection disciplines.

Dr. Gashawbeza Ayalew

Past efforts on managing invasive alien species are documented in PPSE proceedings published in 2012 with a title "Alien Invasive Pests threatening Ethiopian Agriculture." The impacts of these efforts particularly against invasive plant species are well documented. Current efforts against other disease and insect pest (IAS) are also well documented.

Dr. Emana Getu

What will be the next to curb the alarming pest situation? We have to put some resolution, etc. Do we have examples of diseases which change their niche due to climate change? The current problems of pests and diseases are mainly due to structural problems. Hence, EIAR and MoA should revise their organizational structure. The structure in place 20 years ago is better to solve the problems. Professionals from where ever they are should be utilized.

Ato Fikre Markos

Reporting the occurrence of new pests to the secretariat of IPPC is the obligation of the NPPD of member countries. Not complying with this is a weakness. We should properly recognize the scope of plant quarantine. It is not a pancake for everything. About Invasive alien species, the issue is beyond plant protection, it concerns environment, biodiversity and phytosanitory service. Hence, coordinated action is important. Categorization of plant pests is taken care but we need updating it.

Ato Alemayehu Woldeamanuel

Most of the presenters in the morning told us the challenges, problems, issues in relation to pest management in the country. But it would have been good if the presenters told us the interventions to address those issues and the positive impact gained as the result of the interventions. So that we can capitalize on those efforts made.

Dr. Eshetu Derso: Altitude on pests does not have any things to do with disease development. It is the weather variables that are important.

Dr. Mohammed Yesuf

Fungal pathogens reported as causes of aflatoxin are known to cause pre-harvest and post-harvest diseases of fruits and vegetables. Is there any information on these pathogens as causes of aflatoxins on fruit and vegetables?

Dr. Wakitole Sori

The permissible level of mycotoxin is very low in milligram/microgram per kilogram. If we see the dosage of mycotoxin on grains in developing countries it is easy to imagine that these have been consuming over and above permissible level and there was no such mass death. Thus, is there a sort of co-evolution like? Like synthetic chemicals is there an issue of Bio-Magnification of mycotoxin along the thropic level?

Dr Emana Getu

Why not all this mould kills people? No information on the number of deaths due to mycotoxin. What will happen to the mycotoxin in the food chain? Not much change.

Dr. Adane Aberaham

The information I have is that mycotoxin contamination in Ethiopia is lower than in other countries. So could it be possible that in the presentation today its importance is exaggerated. Is there specific mycotoxine - crop combination while the level is more than accepted threshold level?

Dr. Kemal

Can mycotoxin be minimized by processing i.e heat or cold? Eg. Sorghum and coffee processing.

Dr Emana

For the question, what will happen to mycotoxin in the food processing system? For example where coffee is roosted not much change observed.

Dr. Gashawbeza Ayale

Application of pesticides such as chloropyrifos and profenofose have been reported to lower the cholinesterase level of workers involved in handling pesticides. However, the normal levels of cholinesterase for healthy individuals fall between values, lower and higher limits. What does high cholinesterase mean for worker involved in handling pesticides?

Professor Yalemtsehay

Toxicity of pesticides in human was measured in terms of the level of cholinesterase enzyme. The enzyme level has a normal range; if it is greater than the normal range the works feel unhealthy. But if the worker is exposed to the pesticides for long time it could result in disability of muscular contraction etc.

Dr. Bayeh Mulatu

Pesticides are poisons and I totally disagree with what Ato Alemayehu has suggested. We need to use PPD (personal protective devices). Can we see your focus extended beyond human health? As pesticides are affecting natural pest control factors.

Dr. Kemal All

How do you measure the toxicity levels of pesticides to human?

Professor Yalemtsehay

Environmental impact of pesticides on soil and water was checked in Meqi area some years ago. It was found to have some pesticide residue.

Dr. Bayeh Mulatu

What have they said at AU regarding the management of mycotoxine by smallholders who are at high risk for these toxins?

Dr. Emana Getu

Regarding the question what was decided on AU Aflatoxin meeting, Ethiopia is not the pilot site.

Summary and Recommendations of Discussion

Chair Person: (Dr. Ferdu Azerefegne)

Summary

From the presentations and reflections made by the participants during the plenary session it was clearly showed that, even though there were a number of success stories for PMSS in the Ethiopia and the pest management support service system general situations have been fully understood by decision makers in the MoA, the current pest management support service in the country stands in its weakest level and there is an urgent need to reinvigorate it. Currently, Plant protection discipline and related issues received less attention by decision makers. The indication was repeated reorganization of the support service underwent; the weaker organizational structure adopted, national plant protection laboratories are not operational at the moment, low resource allocation and limited capacity building. The career structure of plant protection professionals, plant health clinic experts and the quarantine post workers is very much undermined at national and regional level. These resulted in the attrition of trained personals to other better paid fields. Even from the research side, generation and adaptation of new plant protection information and technologies was very low. Moreover, in higher learning institutes fewer students join plant protection fields of study and thesis researches in crop protection conducted in all the Universities are uncoordinated, less known to the crop protection community and not disseminated to wider users. Besides, the participation by plant protection professionals in plant protection national forums including the annual conference of the PPSE has declined. Due to climate change and weather shift a number of emerging and reemerging insect pests, plant diseases and weeds threatening the agricultural production of the country. The issue of postharvest pest management and mycotoxin problem needs higher attention. Pesticide use and human health hazard in an important issue to get attention. It was also suggested that, in order to save the country from the ravage of pests and to deliver effective PMSS, it is essential that Ministry of Agriculture, EIAR, RARIs and all the principal institution engaged in plant protection research, extension and training activities should take the responsibilities and design appropriate policy, strategy and legal frameworks and put in place to assist implementation of PMSS.

Recommendations

In order to benefit significantly from the favorable policy environment created, it is essential that Ministry of Agriculture, the principal institution for successful implementation of pest management support system in the country at large, carry out required activities to "promote pest management in the smallholder agriculture by focusing on IPM". Therefore for better provision of pest management support service, the following activities need to be fulfilled:

- Design appropriate policy, strategy and legal frameworks and put in place to assist implementation of PMSS
- Developing guideline on better ways of implementation of pest management support service with significant focus on promotion of IPM in Ethiopia;

- Re-establishing a functional pest management support service system nationwide/countrywide and making it fully operational;
- Creating a sustainable linkages between the different actors at all levels;
- Enhancing the federal and regional plant protection laboratories and putting in place the required human resource to provide pest identification service, pre- and in-service training in pest management to all who need it;
- Having pest management training modules for college and university students, experts, development agents and farmers developed/harmonized, continually improved and utilized
- Enhancing pest management training capacities in all woredas and kebeles across the country
- Sustaining pest management support program in the smallholder agriculture by promoting community-based sustainable pest management and crop production by introducing farmers field school as a viable approach;
- Putting in place an information and coordination system to monitor progress, support policy and ensure transparency and accountability in the support service provision;
- Develop, produce and distribute different guidelines to all users, which include: updated check list of pests present in Ethiopia, updated checklist of quarantine pests in Ethiopia, improved pest identification and control guidelines, improved pesticide regulation guideline, Biological control agents use guideline, Biopesticides and Botanicals use guidelines, updated Quarantine/Phytosanitary legislation and Domestic Regulation, Integrated Pest Management promotion guidelines and Improved postharvest pest management guidelines.
- Improve the career structure of Plant protection professional at National and federal level.

- Enhance the capacity and skill of Plant protection professional through short and long term training.
- The issue of postharvest pest management and mycotoxin problem, reduction of Postharvest crop losses needs higher attention.
- Pesticide handling, pesticide use and its effects on human health hazard is an important issue to get higher attention in the future.

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ISBN 978-99944-952-5-2
9 789994 495252 >
Printed by Eth-Cana P.Plc