Assessment of Pest Diagnostic Capacity in Plant Health Related Laboratories in Kenya

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This IPM series record assesses pest diagnostic diagnosis service provision capacity of Plant Health laboratories in Kenya. . The intent is to capture better understanding how they are performing in the country in identifying established and potential invasive pests affecting agricultural production and productivity. The series also ensures that recorded data and other information gathered, generated and analyzed are part of the research work of International Centre of Insect Physiology and Ecology (http://www.icipe.org). The series is reviewed internally by icipe staff. It can be freely accessible both in hard copy and electronically and cited due acknowledgement.

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About ICIPE
icipe*'s* mission is to help alleviate poverty, ensure food security and improve the overall health status of peoples of the tropics, by developing and extending management tools and strategies for harmful and useful arthropods, while preserving the natural resource base through research and capacity building.

The Centre's vision is to pioneer global science in entomology, to improve the wellbeing and resilience of people and the environment to the challenges of a changing world, through innovative and applied research, alongside deep exploratory study, impact assessment, evaluation and sustainable capacity building.

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ACRONYMNS

ELISA	Enzyme Linked Immunosorbent Assay Technique
ICIPE	International Centre of Insect Physiology and Ecology
IPM	Integrated Pest Management
ISO	International Standards Organisation
KARLO	Kenya Agricultural Research and Livestock Organisation
KEPHIS	Kenya Plant Health Inspectorate Service
NMK	National Museums of Kenya
PCR	Polymerase Chain Reaction
QA	Quality Assurance
SOPs	Standard Operating Procedures
USAID	United States Agency for International Development

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EXECUTIVE SUMMARY

Pest diagnosis is a gateway to Integrated Pest Management (IPM) implementation. Timely and accurate diagnosis of new and established pests that pose a significant risk to East African agriculture is important in alleviating food security. Undetected pests may exist in a country and threaten agricultural crops and the environment. Expanded surveillance, networks of expertise, pest risk assessments, and access to improved diagnostics will help for early detection, to prevent pest damage and crop losses, and to protect the environment.

The main purpose of this work was to assess the pest diagnostic capacity of national research systems and agricultural service providers in Kenya in order to improve production and productivity of crops while reducing the risks derived from pest threats against plant health and food safety.

This report presents summarised results of questionnaires, interviews and observation checklists collected from government, university and private diagnostic centres across Kenya. Over 60 informants involved in the questionnaire from plant pest diagnostic laboratories. The survey achieved high response rate (67 per cent response). All of the major government laboratories responded to the survey, while some non- governmental laboratories declined to participate.

1. BACKGROUND

1.1 Historical perspective of agriculture in Kenya

Over one billion people worldwide continue suffering from hardship hunger caused by increasing population growth, economic instability and climate change. In such circumstances, food security has become major national and global concern which require immediate response.

Agriculture is a crucial economic activity for most African countries, providing employment, livelihoods, and well-being of up to 70% of the population. It contributes about 3% to the world's total Gross Domestic Product (FAO, 2011). Majority of Africa's population are extremely poor and live in rural areas and highly depend on agriculture for their survival. In Kenya, Agriculture contributes 24.5% of the Gross Domestic Product (GDP). This makes it one of the economic pillars of the country‘s Economy (Government of Kenya, Agricultural Sector & Strategy, 2010). The sector also accounts for 65% of Kenya's total exports and provides more than 18% of formal employment.

1.2 Evolution of pest diagnosis in Kenya

Among the numerous constraints to crop production are the damage caused by agricultural pests and diseases which contributes significantly to the reduction of crop yield. With the rapidly changing climatic conditions, farmers are facing many challenges including new crop diseases and pests. Some of the pests and diseases are completely devastating, thus, it calls for new approach that deal with the emerging challenges.

In Kenya, agricultural pest diagnostic services have over the years been provided by the Ministry of Agriculture and Livestock which was devolved to counties. However, non-governmental organizations (NGOs) have supported the provision of these services in small pockets of the country where they undertake their activities. Private sector actors have also been providing these services, but only to specific large scale farmers who employ their own extension officers working on farms. Usually, farmers carry over the costs associated with agricultural pest's diagnostics services.

Various techniques are used in the pest's diagnostics, but the techniques vary from one pest to another. Agricultural pests are identified using morphological characteristics and digital imaging technology that helps to capture detailed images of suspected pests. With the help of this device, the suspected pests then be transferred electronically to qualified specialists for identification. Additionally, with advancement in technology, use of molecular diagnostics such as DNA barcoding is gaining popularity in the identification of pests worldwide. The use of molecular diagnostic methods allows speed and precision of the identification process of insect's pests.

Plant disease identification mainly relies on several methods. Since a single plant may be co-infected by more than one pathogen, each of methods must be reliable and not overly exclusive. Proper identification of plant disease causes at early stage is crucial for successful management. Delaying the identification would result in extensive crop damage and liable the farmers to financial loss. Some diseases can be diagnosed quickly by visual examination. However, visual detection at plant level is reactive response. This is because it detects after the major damages on the crop already happening. Other diseases require laboratory testing for diagnosis. New diagnostic techniques are now available that require minimal processing time and are more accurate in identifying pathogens. These diagnostics are based on rapid detection of proteins or DNA that are specific to each pathogen, disease or condition. Some procedures require laboratory equipment and training, while other procedures can be performed on site by a person with no special training.

Examples of existing diagnostic techniques

- **Enzyme-Linked Immunosorbent Assay (ELISA) kits**: are based on the ability of plant pathogen antibody to recognize a certain protein substance or antigen associated with a plant pathogen. The kits are very easy to use; some tests can be used in the field where a disease is suspected and can take only 5 minutes to identify.

- **Direct Tissue Blotting**: This technique also utilizes specific antibodies to detect the presence of plant pathogens. In this method, affected tissue samples are pressed to draw out proteins onto a special paper and the antibodies are added to the sample. A colour-inducing reagent is added afterwards to react with the antibody-pathogen complex. Colour reaction indicates a positive result and pinpoints the location of the pathogen in the affected tissue.

- **DNA/RNA Probes:** Another set of tools that can be used in plant disease diagnostics is nucleic acid (DNA/RNA) probes. These probes are fragments of nucleic acid arranged in a sequence complementary to the DNA or RNA of the pathogen. Because the sequences complement each other, the probes can be used to identify specific diseases.

- **Polymerase Chain Reaction (PCR)** also uses nucleic acid probes to detect the presence of a pathogen. This is a lot more sensitive compared to the other techniques as PCR can detect very small amounts of a pathogen's genetic material per sample and amplify certain sequences to a detectable level. Polymerase chain reaction (PCR) can be used to detect the presence of pathogens in the air, soil, and water. Spores, especially those produced by fungi, are the primary source of infection to initiate epidemics. This can greatly help farmers in predicting possible diseases and the extent of the damage it can bring. It can also help farmers to detect the presence of pathogens that have long latent periods between infection and symptom development. Farmers can therefore keep track of the pathogen and apply the necessary control to prevent the spread of the disease. PCR can also be used to detect the occurrence of mutations in a given population of pathogens. These genetic mutations lead to the development of resistant strains. The development of molecular test kits can be expensive but the returns are great. Further, they have short commercial timeframes, few regulatory barriers (because they are not consumed), and can be marketed widely, including directly to farmers.

Failure in timely diagnosis of diseases and other pests has often been responsible for devastating yield losses at national. Regional and global levels.

1.3 Importance of pest diagnosis to national economy and food security

Agricultural pests and pathogens pose a major threat to food security and the natural environment, and these threats are moving around the globe. On average 35% of worldwide potential crop yield is lost during pre-harvest by pests (Oerke 2005). Coupling with growing population, climate change and other devastating pressures the crop losses by pests and disease are major challenges for national and global governance. To keep the pace with growing population, global food production needs about 70% increases by 2050. Thus, tackling crop losses caused by pests has many fold benefits; to ensure food security and to boost economic growth, to create employment opportunities and substantially reduces poverty in low-income economies in Kenya.

In order to achieve this, accurate diagnosis of pests and disease, as well as existence of credible management are vital. In the absence of strong national pest's diagnostic capability there would be an increase in crop losses from pests and diseases, chemical control and associated costs. To assess pest diagnostic capacity of a laboratory, it is critical to analysis it's Strengths, Weakness Opportunities and Threats (SWOT) because these laboratories can tap to excel in that specified discipline.

1.4 The SWOT Process and Methodology

SWOT is a management technique (strategic tool) developed at Stanford University in the 1960's using data from Fortune 500 companies. It evaluates Strengths (S), Weaknesses (W), Opportunities (O) and Threats (T) in achieving objectives. SWOT identifies internal factors and external conditions that are favourable and unfavourable to achieve specific objectives (Houben *et al.*, 1999; Kaplan *et al.*, 2008). Strengths relate to competitive advantages (e.g. resources, competencies), weaknesses are limitations that hinder progress, opportunities are conditions favourable for achieving goals, and threats are conditions harmful in achieving goals.

Using SWOT model, the study describes current diagnostic situations, identified strengths and gaps, and suggest measures that will lead to a strong and viable national diagnostic service in Kenya.

2. SURVEY METHODOLOGY

A survey methodology comprised of questionnaires, interview guides and observation checklist. The questionnaire comprised of 46 questions and was designed in consultation with the consultant carrying out similar work in Tanzania. Organisations providing plant pests diagnostic services in Kenya was sorted using yellow pages, and through established networks with the industries. The intent was to capture information from government laboratories, universities and the private sector. The author designed an online questionnaire database. This questionnaire was sent via e-mail and the respondents entered their responses directly into an electronic database. Face to face interviews were conducted in sampled laboratories and the laboratories were visited in gathering more information about the operations. Reaching 60 respondents was maximum sample size the study targeted. Every survey response was checked carefully and unusual answers were double-checked by establishing direct contact with the service provider. All responses were kept confidential.

The questions were designed to address four critical attributes of a plant pest diagnostic laboratory.

1. Business/management systems
    - The primary mandate of the plant laboratory and type of samples analysed.
    - Identification of the laboratories conducting SWOT analysis.
    - Sources of revenue/funding.
2. Equipment's, infrastructures, laboratory assurance and standardization
    - Assessments of essential equipment's in pests diagnostics laboratories
    - Adoption of modern technology (biochemical and molecular techniques)
    - Accreditation status of the laboratories, validated tests and standard operating procedures for pests and diseases among the laboratories

- Links with reference laboratories and specialist who have expertise in pests identification

3. Human resources and training
    - Staff expertise, capacity and experience
    - Attendance of relevant trainings by the staff involved in day to day pests diagnosis in respective laboratories
    - Recommendation of relevant trainings for diagnostician
4. Data base management and networking
    - Access to the Information Computer Technology (ICT) and high speed internet
    - Availability of pests database
    - Networking capacity of the laboratories

3. ANALYSIS

3.1 Pests diagnostic laboratories surveyed

Responses were received from eight agricultural pests and diseases diagnostic laboratories in Kenya including: Egerton University, *icipe*, KARLO-Food crops research centre Njoro, KARLO-Kitale, KARLO-Tigoni, KEPHIS, Plant Quarantine and Biosecurity unit - Muguga and Jomo Kenyatta International Airport (JKIA), National Museums of Kenya and University of Nairobi (Table 3.1). Respondents from the laboratories surveyed indicated 80.6% of the laboratories played a primary role in pest diagnosis while 13.9%were not primarily involved in pest diagnosis and only 5.6% involved in certain extent.

Results of the survey showed all laboratories participated in agricultural pest's diagnosis, but i*cipe*, KARLO-Njoro, KARLO-Kitale and National Museums of Kenya (NMK) playing significant roles in maize pest and diseases. *Maize lethal necrosis virus* (MLNV), smuts and bunts, loose smut, leaf hoppers, larger grain borer, and thrips (Table 3.1) were among maize diseases and pests identified in these laboratories.

Wide variations in pest identification responsibilities was noted among the laboratories. Egerton University, KARLO- Kitale and University of Nairobi (UoN) are mainly involved in diagnosis of non-regulated pest of national concern. KARLO-Njoro, KEPHIS, National Museums of Kenya and *icipe* are involving in identification of non-regulated, non-quarantine, quarantine and regulated pests however KARLO-Tigoni is the only institution engaged with quarantine pests.

Table 3.1: Pest and diseases data in all labs

institute	Egerton	*icipe*	KARLO- Njoro	KARLO- Kitale	Karlo-Tigoni	KEPHIS	NMK	UoN
Pest	leaf hoppers codling moths, aphids, thrips,	*Tuta absoluta*, Thrips,DBM), **Larger grain borer,** Fruit flies, Coffee berry borer	Cereal aphids, mites, white flies, bean fly, barley fly, **loopers, amyworms, stalk borers,** sawflies, Bean Fly, aphids, **Maize Stalk Borer, maize,Thrips**	Crop pests of (pastures, **maize,** beans, sweetpotato, cabbages)		False Codling Moth, Aphids, White Flies, *Tuta absoluta*, Mealy bugs and Thrips,	All field and storage pests	aphids, whiteflies and bean fly
Diseases	Cucumbe r mosaic viruses,	*Iris yellow spot virus, Tomato spotted wilt virus* **Maize lethal necrosis virus (MLNV)**	Wheat rusts, Septoria diseases, spot blotch,Tan spot, loose smut, Fusarium head blight, Sclerotina wilt, Canola diseases, Soybean diseases, Common bean diseases, MLNV potato blights,	Crop disease (pastures, maize, beans, sweetpotato, cabbages)	Potato viruses	Bacterial wilt, Cassava Mosaic Virus, **MLNV** Bean Common Mosaic Virus, Early Blight, Late blight		purple blotch, thrips, leaf hoppers, powdery mildew, diseases affecting roses, **MLNV**

All the surveyed laboratories collect data and obtained their samples through their own sampling and from farmers. Four laboratories including *icipe*, KARLO- Kitale, KEPHIS and National museums of Kenya received samples from government agencies. Egerton and NMK are the only insitutions that received samples from other laboratories. Apart from the identified sources, KEPHIS got samples from plant inspectors, seeds department and international collaborators (Figure 3.1). This is an indictation of low/loosly networking among agricultural pest identification institutes in Kenya.

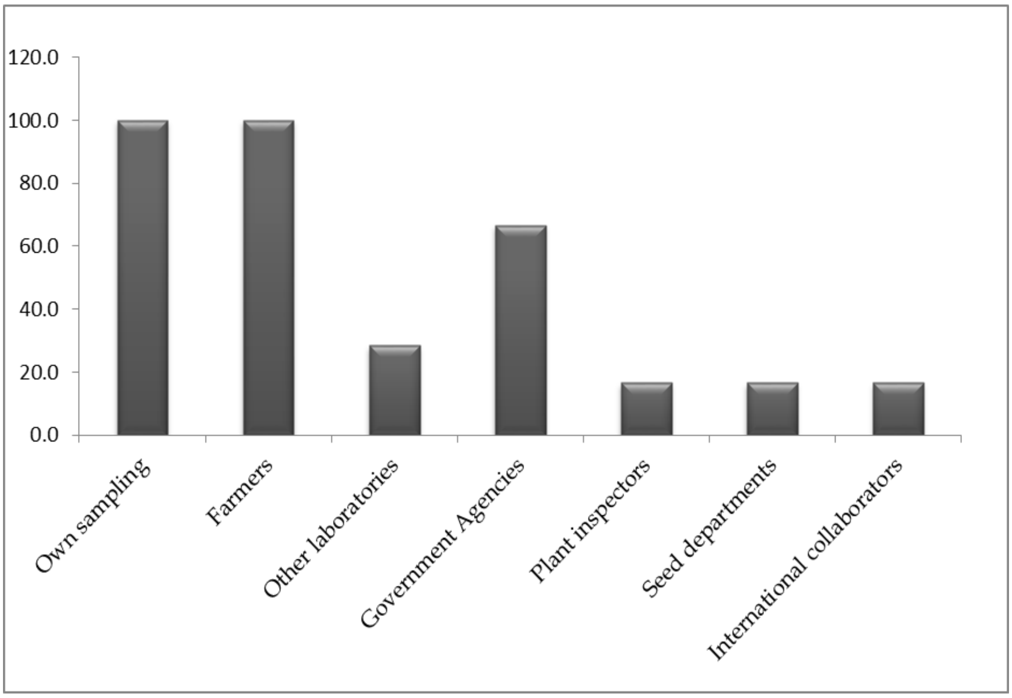


Figure 3.1: Percentage of the pest and disease diagnosis sample sources

Although there were wide sources of samples, only 25% of the respondents indicated the laboratories had the capacity to cover the national demand for agricultural pest's identification services. 38.9% of respondents expressed that the laboratories covered only to certain extent and 36.1% reported the laboratories did not have the capacity to cover national demand.

3.2 Strengths, Weakness, Opportunities and Threats (SWOT) analysis

3.2.1 Strengths of pest diagnostic labs

Various laboratories have different strengths (Table 3.2).

Table 3.2: SWOT analysis per individual laboratory surveyed

Institutions							
Egerton	***icipe***	**KARLO-Njoro**	**KARLO - Kitale**	**KARLO-Tigoni**	**KEPHIS**	**NMK**	**UoN**
Strengths							
Technology transfer	Training the farmers	Funded project	Training farmers	Training farmers	Training the farmers	Accredited	Training farmers
Conducting trainings	skilled personnel	Technology transfer		Highly skilled personnel	Fast diagnosis and funded projects		skilled personnel
Skilled personnel	Technology transfer	Training farmers			Accredited-ISO 17025		
Weakness/Threats							
Inadequate funds	Changes in technology	Inadequate funds	Changes in technology	Inadequate funds	Changes in technology		Inadequate funds
	inadequate funds	Inadequate/poor equipment's		Changes in technology	Inadequate equipment's		
		lack of skilled personnel			Lack of skilled personnel	Lack of skilled	
		Inadequate lab space			Inadequate funds		
					Lack of transparency & disconnect between researchers		
Opportunities							
Adoption of new technology	Adoption of new technology	Adoption of new technology	networking	Adoption of new technology	Adoption of new technology	Networking & databases	Adoption of new technology
new funding programs	Networking	Networking			networks and training	Adoption of new technology	Networking
	databases	databases	training	training	more funding	training	databases
Training	training	more funding	Funding		Databases	Funding	training

i. All laboratories stated are actively engaged in providing training for farmers, extension officers and technicians (Table3.2; Figure 3.2)

ii. Technology transfer was reported as a major strength by respondents from *icipe*, KARLO-Njoro and Egerton University. These three laboratories disseminated the information obtained from the laboratories to farmers, extension officers who are their direct beneficiaries.

iii. Funding projects was reported to be a strength in only two institutions; KEPHIS and KARLO-Njoro .

iv. Acreditation: KEPHIS and NMK are the only labs accredited for agricultural pest identification. They awarded ISO 17025 by KENAS and Bureau Beritas respectively (Figure 3.2)

v. Egerton University, *icipe* and University of Nairobi are reported labs which have highly qualified and skilled personnel that gave them an edge over other laboratories. (Table 3.2; Figure 3.2)

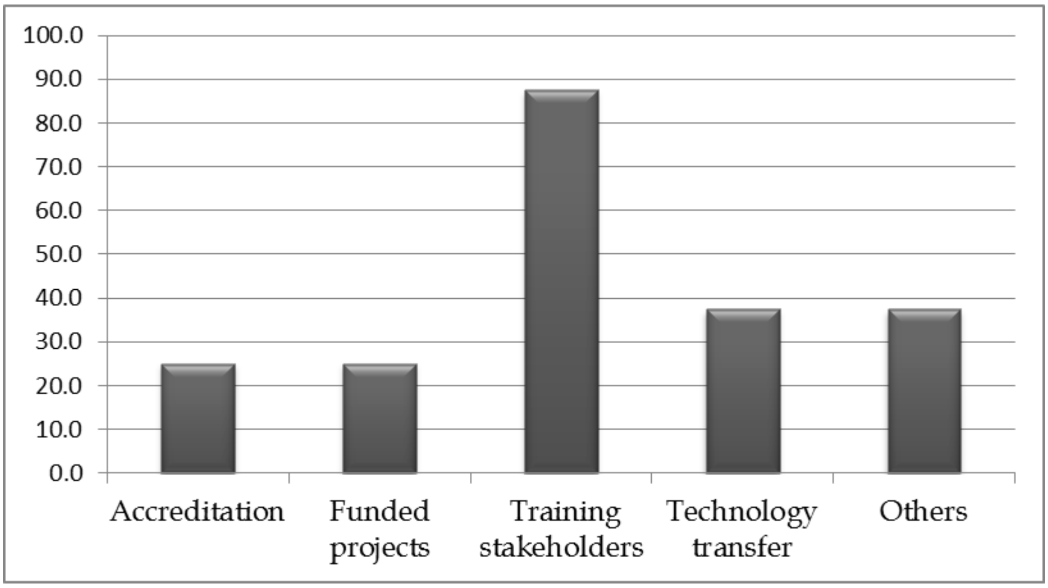


Figure 3.2: Percentage of individual strength's of the laboratories

3.2.2 Weaknesses/threats facing pest diagnostic laboratories

A range of areas identified where the surveyed laboratories need to improve in order to outperform their competitors (Table 3.2). Currently, there are also laboratories fail to perform efficiently in these areas but they had ability to reverse these challenges into strengths. Major challenges facing the pest diagnostic services in Kenya include:

i. Funding gaps: 75% of the laboratories reported they are facing of funding. This is a threat to their future plan to perform diagnostic services. This funding constraint arises due to the assumption that proposing fee for the service. It can meet the funding shortfall created by cut backs on government budgets and donors (Table 3.2; Figure 3.3)

ii. Changes in technology was reported as a significant threat (50%) leading to underperformance in four laboratories, namely: KEPHIS, *icipe*, UoN and KARLO-Tigoni.

iii. Human resources: Three key areas were identified as key impediments in relation to human resources capacity: lack of skilled personnel, understaffing and lack of on-job trainings aimed at capacity building of the personnel involved in pest diagnosis. Respondents among the laboratories indicated they did not have programmed trainings. Only 22.2% expressed that they had at least one training per year. Lack of skilled personnel (37.5%) was reported in KEPHIS, KARLO-Njoro and Egerton University (Table 3.2; Figure 3.3)

iv. Inadequate/non-functional equipment's: KEPHIS and KARLO-Njoro also indicated lack of equipment's as contributor to low performance. This mainly as a result of the funding constraint they experienced.

v. Other challenges experienced in agricultural pest's diagnostic laboratories included; disconnect between the researchers and extension officers and limited transparency in decision making which were encountered at KEPHIS (Table 3.2; Figure 3.3)

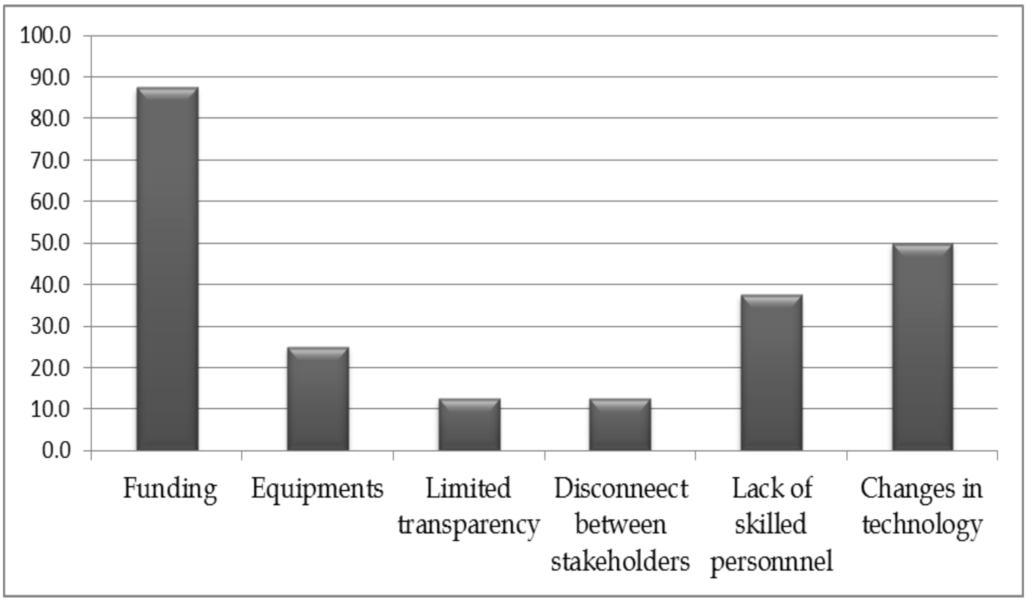


Figure 3.3: Percentage of individual weakness/threats in all laboratories assessed

3.2.3. Opportunities for pest diagnostic labs

Agricultural pest diagnostic laboratory in any country should capitalize on opportunities it finds and use these situations to make profit and grow. Based on survey responses the following opportunities exist for pest diagnostic labs in Kenya.

a) **Adopting new technologies:** 75% of the labs have the capacity to accommodate emerging technologies. These new technologies include adopting the use of biochemical and molecular techniques such as ELISA, standard PCR, Real time PCR and DNA barcoding for agricultural pests identification. The technologies will help the labs to develop new core business areas in entomology and disease diagnosis.

b) **Engagement and networking:** 87.5% of the laboratories surveyed reported new alliances with stakeholders associations and research network within the pest diagnostic laboratories in Kenya will offer them unique opportunity to achieve research advancement (Table 3.2; Figure 3.4).

c) **New funding programs:** were indicated to be among potential impact category that would benefit agricultural pests and diseases diagnostic labs across Kenya. 62.5% of the surveyed labs have funding opportunities.

d) **Pest databases:** 62.5% of the respondents suggest that having open access to databases for agricultural pests and diseases will boost the identification of pests and implementation of appropriate control strategies

e) **Trainings:** 87.5% of the respondents stated that on-job trainings of the staff undertaking plants pest and diseases diagnosis will have a huge impact on the performance of the laboratories (Figure 3.4)

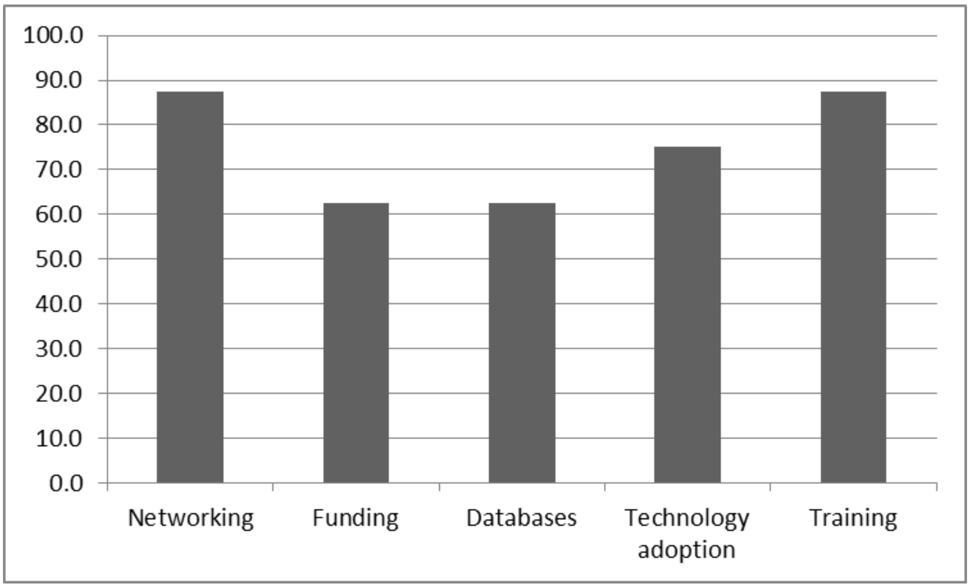


Figure 3.4: The opportunities of the laboratories for pest diagnosis

3.3 Equipment’s, infrastructures, laboratory assurance and standardization

3.3.1 Equipment’s and testing services

The laboratories have basic equipment’s used for routine diagnosis of pest and diseases including laminar flow hood, biosafety cabinet, autoclaves, fridges, compound and stereo microscope (Table 3.3). Although molecular techniques play a major role in the identification of new species of pests, only 50% of the laboratories are equipped with PCR machine while 37.5% of the laboratories had Real time PCR (Table 3.3)

Table 3.3: Range of equipment’s in various laboratories

Equipment's	% Laboratories with functional equipment’s	% Laboratories without functional equipment’s
Laminar flow hood	100	0
Biosafety cabinet	75	25
Autoclave	87.5	12.5
Fridges	87.5	12.5
Freezers - 20	75	25
Freezers - 80	50	50
Bench centrifuges	62.5	37.5
Orbital shaker	62.5	37.5
Pipettes	87.5	12.5
Compound microscope	100	0
Stereomicroscope	62.5	37.5
ELISA reader	75	25
ELISA washer	62.5	37.5
PCR machine	50	50
Real time PCR	37.5	62.5
Sequence	25	75

All the laboratories surveyed relied on the use of morphological and microscopy for agricultural pests and diseases identification (Figure 3.4). Although traditional methods play a major role in the identification of pests, they are time consuming and inaccurate especially where the experts are not available in specific fields and this might eventually result in misleading outcomes.

During reporting period, of total laboratories surveyed, only 62.5% relied on biochemical techniques for routine diagnosis while 37.5% used molecular techniques (Figure 3.5). Labs which are not using molecular techniques to test agricultural pests, 38.1% attributed to high cost of PCR primers and reagents. According to some respondents (33.3%) this was due to lack of infrastructures to accommodate molecular equipment’s.

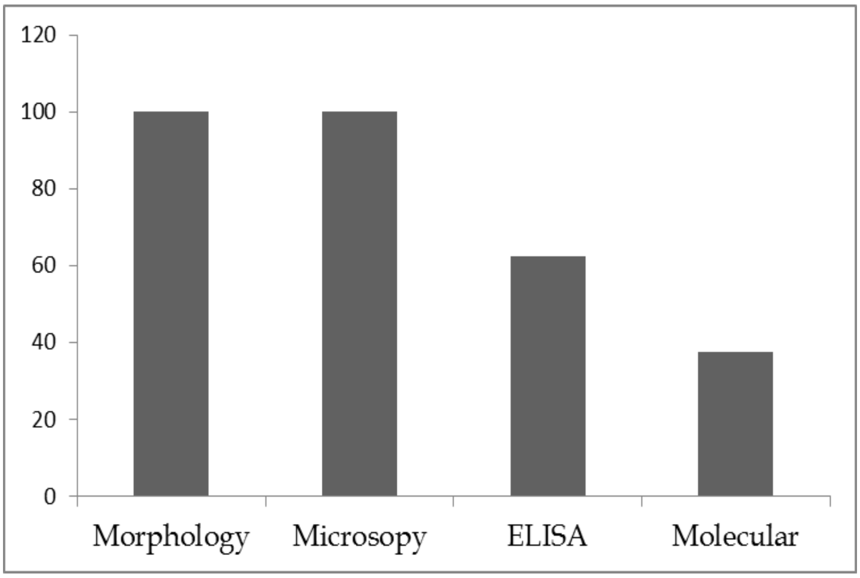


Figure 3.5: Techniques applied for routine diagnosis across all laboratories

Respondents also reported they do not have adequate access to computers, cameras and reference materials in their labs. The latter is particularly important, since only 54.5% of the respondents considered their libraries adequately acquire reference materials on plant pests and disease diagnostics. In many laboratories, reference materials were out dated and/or in short supply. In the absence of experts, the availability of appropriate compendia is crucial for the identification of pests and disease.

The survey showed KEPHIS, KARLO-Food crops research centre- Njoro and *icipe* research institutes are the only facilities that offer range of biochemical and molecular tests for pests and diseases. The reason for this difference between laboratories is probably due to high equipment and infrastructure costs that limit other labs to provide the service.

It was also observed that most of the pest diagnostic laboratories in Kenya were established several years ago. Due to lack of financial support these infrastructures have not been upgraded. They have very poor laboratory space and out-dated equipment. Where modern facilities have been put in place through government funding or donation, however, their maintenance budget and sustainability were not adequate.

3.3.2 Accreditation status and quality control

Two laboratories; KEPHIS and NMK are the only laboratories ISO-certified for agricultural pest's diagnostics. Both labs had received ISO 17025 award by KENAS and Bureau Beritas respectively. Majority of the respondents from other labs highlighted the benefits of lab accreditation but also concerned about the costs required to implement the systems. More importantly, the hidden costs that helps to maintain the accreditation values. Six of the laboratories reported to use validated diagnostic protocols with limited mandate to identify exotic pests and diseases. However, the degree of validation of the quarantine tests varies widely between the labs, which indicates a need to develop more consistent approaches and national standards.

3.4 Human resources and training

To maintain a high level of effectiveness on pest and disease diagnosis, plant health laboratories in Kenya should be filled with skilled and competent staff. In addition, the labs should have string supports in resources and tools to perform their work. Therefore, professional skills, staff expertise and significance of relevant training for the staff were areas assessed during this survey under human resource requirements.

3.4.1 Professional skills in plant health laboratories

In terms of balance of professional skills, most laboratories appear to be reasonably well served by the various discipline specialists. However, weed scientists, nematologists and virologist experts were not well represented in all laboratories especially at *icipe*, KARLO-Kitale and KARLO-Tigoni. Entomologists constituted the highest number of specialists in all the labs surveyed (Table 3.4)

Table 3.4 Total numbers of discipline and specialists available in various diagnostic laboratory

Discipline	Egerton	*icipe*	Karlo-Njoro	Karlo-Kitale	Karlo-Tigoni	KEPHIS	NMK	UON	Total
Entomology	5	8	8	6	5	6	8	5	**51**
Bacteriologist	2	4	5	4	2	4	3	6	**30**
Mycology	3	4	4	4	3	8	2	3	**31**
Nematology	2	1	2	2	1	2	2	2	**14**
Virology	2	2	3	3	1	3	1	2	**17**
Weed science	2	0	2	0	0	2	1	1	**8**
Total	**16**	**19**	**24**	**19**	**12**	**25**	**17**	**19**	**151**

In terms of numbers the diagnosticians across all the labs. 45.7% of the respondents ranked that average availability of diagnosticians, while 20% reported they were sufficient (Figure 3.6). This calls for the recruitment of more personnel involved in pest diagnostics in all plant health laboratories

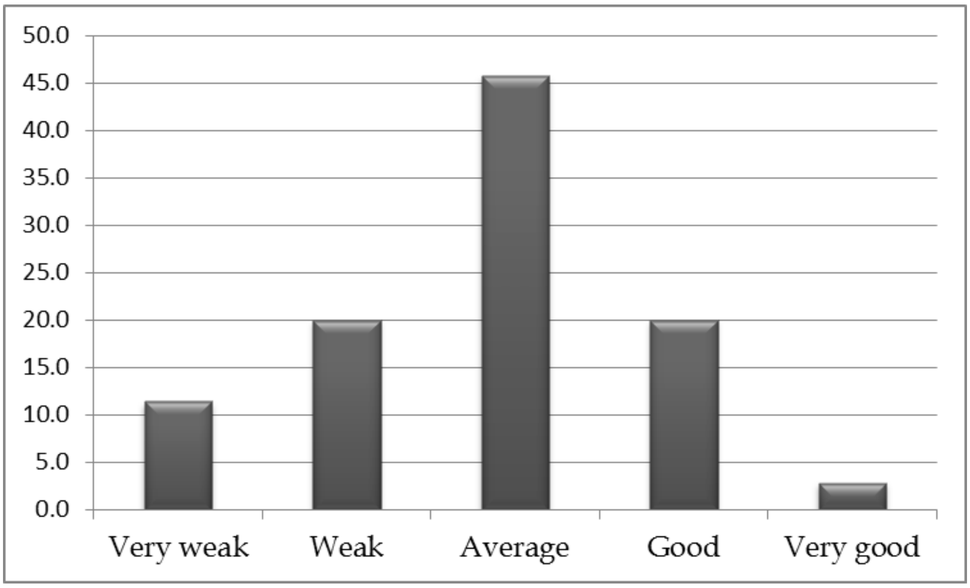


Figure 3.6: Rating of human resources capacity in the laboratories surveyed.

Of the total respondents, 67.7% were qualified and trained in pest diagnostics, and acquired relevant experience to use laboratory equipment's and analytical methods. Majority of the diagnosticians (72.4%) were Bachelor degree holders followed by Master's degree holders (54.8%). Diploma and certificate holders are 41.9% while Doctorate (PhD) accounted for 25.8% of the total respondents.

3.4.2 Staff Experience

For all professional groups except nematology and weed science, the average length of experience exceeds 8 years, which indicates that specialists supporting diagnostic services are quite experienced. However, it is also an indicator that these specialists support base is ageing, which highlighting the need for succession plan (Table 3.5).

Table 3.5: Experience of professional staff carrying out pest diagnosis in sampled laboratories

Discipline	Average experience of individual scientists (in years)
Entomology	**12**
Pathology	**8**
Bacteriology	**10**
Mycology	**9**
Virology	**8**
Nematology	3
Weed science	5

3.4.3 Capacity development packages for the diagnosticians

It was noted during the survey that on-job training programs for the staff involved in pest diagnostics were not programmed. 63.9% of the respondent share this argument and only 22.2% of them indicated they attended only one training per year (Figure 3.7)

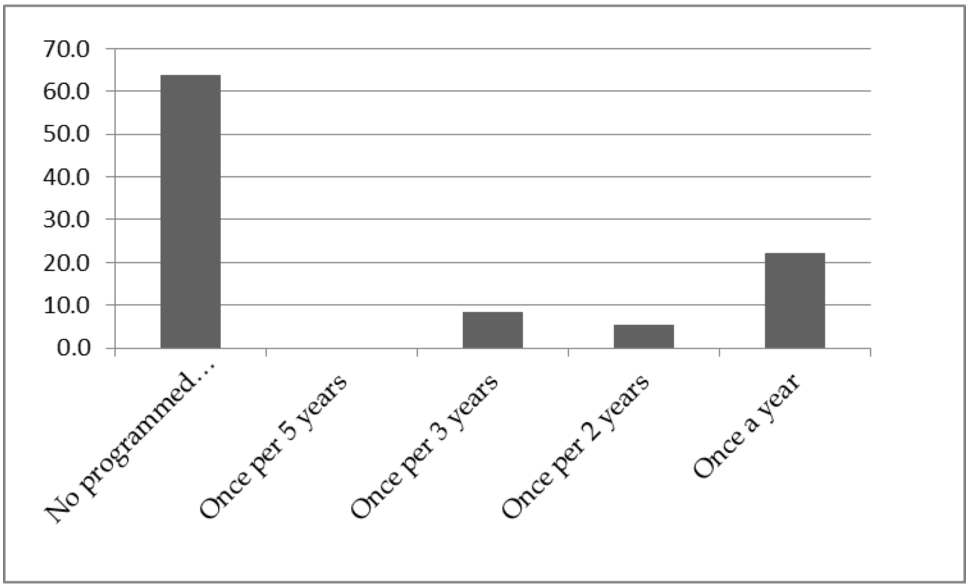


Figure 3.7: Training provided for staff serving as agricultural pests diagnosticians.

3.5 Relevant trainings for pest diagnosticians to meet the needs of service users

Although a number of surveyed laboratories had conducted trainings for their staff, the frequency and relevance of the trainings are major impediments. In order to meet the expected needs of the service, the diagnosticians require extensive training and hands-on experience in the identification of pests and pathogens. The training programs for the personnel involved in pest's diagnostics should be designed to:

(a) Reinforce knowledge of traditional plant disease and insect pest diagnostics;
(b) Provide up-to-date information on emerging pathogens and insect pests; and
(c) Introduce new concepts and procedures in pest diagnostics.

The identification of training needs lies with the management of the laboratories. These training can be conducted in terms of short courses offered through continuing education, attendance of national and international courses, workshops and conferences, meetings of interest bodies and visits to other laboratories. Training should be formatted as a combination of lectures and demonstrations, including laboratory and field exercises led by local, regional and international subject matter experts.

The following are recommended trainings that would enhance the efficiency of agricultural pest's diagnostics in Kenya.

a) Plant pests and diagnostic technology training

This will entail training diagnosticians on;

- Hands-on field and laboratory pests identification using microscopy, imaging, culturing, taxonomic keys, internet resources, determinative tests, serology testing by ELISA, molecular identification of pests using PCR isothermal DNA amplification and DNA barcoding
- Use of the above techniques in the identification of the major groups of agricultural pests and in-depth case studies of critical pathogen
- Visual diagnosis and identification of diseases caused by viruses, bacteria, phytoplasmas, fungi, fungal like pathogens and nematodes

b) *Pest diagnostic data management and networking*

This will cover standard forms and database available in Kenya and worldwide, submission of the data in the databases, links to various databases dealing with agricultural pests and diseases identification and networking strategies with other agricultural pest diagnosticians within region and across the globe.

c) *Train the Trainer Program*

This will involve providing training for diagnosticians on; plant pests monitoring, sampling and sample submission, sample storage, transportation, communication protocols and writing standard operating procedures (SOPs) for high risk pests and pathogens.

d) *Biosafety and biosecurity*:

This will cover the use of personal protective clothing (PPEs) in the laboratory, safety and emergency measures while working in the lab, dealing with contaminants and biosafety and biosecurity measures in the laboratory.

e) *Sanitary and phytosanitary issues*

Providing trainings on international agreements and standards, pest risk assessment, hazard analysis and pest management strategies will enhance the capability of pests diagnosticians.

ISO certified and other higher learning institutions in Kenya, such as Karatina University (School of agriculture and Biotechnology), University of Nairobi (Crop protection section) and Jomo Kenyatta University of Agriculture and Technology – Biotechnology section can offer the above short courses to diagnosticians.

3.6 Pests database management

Although internet plays a key role as a source of reference information and networking among the labs, 33.3% of the diagnosticians did not have access to high speed internet. Of the total respondents 61.8% did not have well developed and compatible data systems to collect, store and report information on pest diagnosis.

Pertaining databases, 41.7% reported they aware of agricultural pest's databases, however 52.9% of respondents reported that the databases are not easily accessible. It was also noted that information sources on pests records in Kenya varied significantly. Highest percentage of the pest records was compiled from research institutions (37.1%), from Museums (14.3%), universities (11.4%) and scientific journals (8.6%). Data from ministry of agriculture, unpublished sources and general public data, played an insignificant role in the pest data compilation (Figure 3.8).

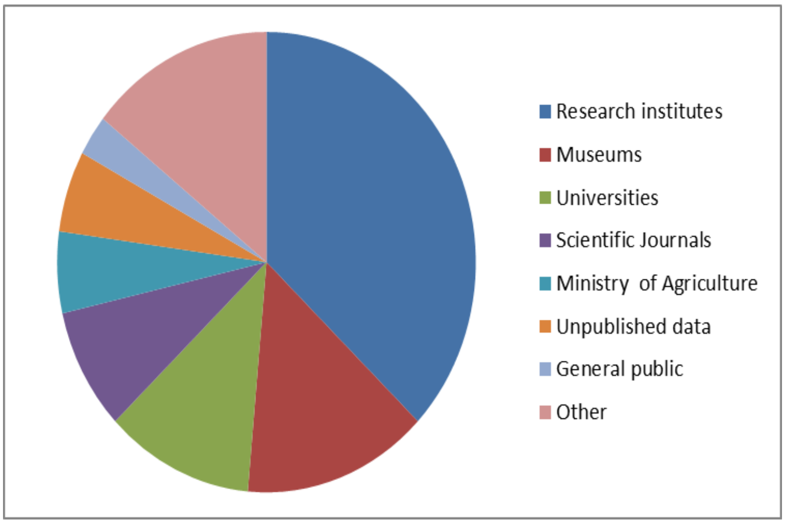


Figure 3.8: Sources of agricultural pest's records in Kenya

Based on these findings, it is thus important that agricultural pest diagnostic labs in Kenya should maintain databases on endemic pests, quarantine, regulated non-quarantine and non-regulated pests of national concern. The databases should be readily accessible to all stakeholders. Agricultural pests database should also incorporate other records related to plant health, for example results of surveillance and monitoring programs, diagnosis procedures (SOPs) and appropriate methods to use, disease free areas, areas of low pest prevalence, phytosanitary import conditions and risk assessments.

3.7 Networking with regional and global pest diagnostic reference laboratories

According to 73.5% of the respondents, plant health laboratories in Kenya are not networked. Several reasons mentioned for the limitations of establishing research networks. Lack of management and operational strategies for developing common vision takes the highest rank (57.1%) for the absence of networking, followed by the use specific legislation and policy framework within each laboratory (32.1%), competitive business environment (7.1%) and finally 3.6% of the networks problems are due to other unknown reasons (Figure 3.9). 26.5% of the respondents laboratories are networked. These respondents are using the following labs for their reference: KEPHIS, Cereal disease labs, University of Minnesota,USA, *icipe*, KARLO- Kabete and Washington University.

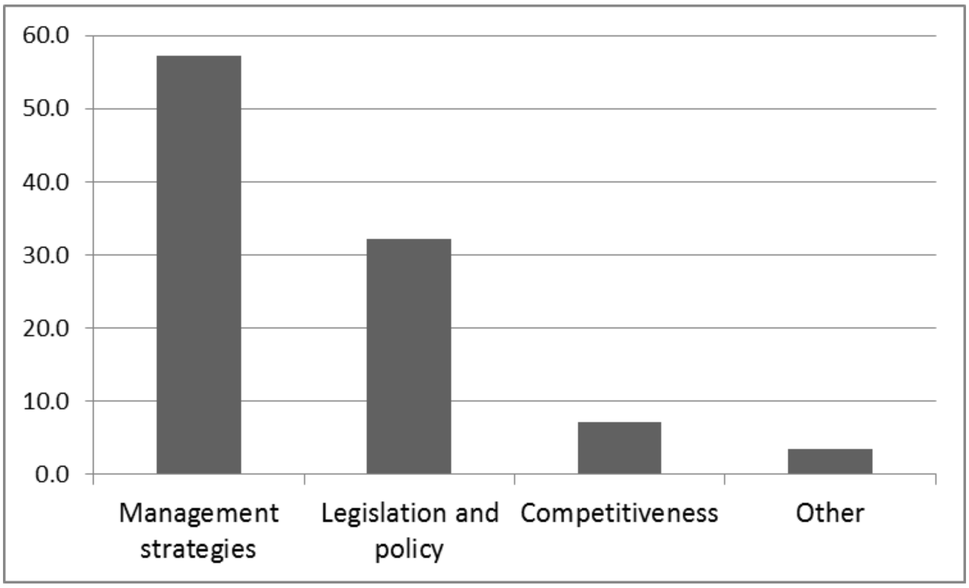


Figure 3.9: Limitations that hinder network formation in plant health labs.

Based on the premises of informants and desk review, the following are list of diagnostic laboratories that can be assumed as reference labs in East Africa agricultural pest diagnostic initiative (Table 3.6).

Table 3.6: List of reference laboratories that can as support laboratories in Kenya

Reference Laboratory	**Contact address**
Ethiopia Institute of Agricultural Research (EIAR)	http://www.eiar.gov.et/
International Center for Tropical Agriculture (CIAT)	www.ciat.cgiar.org
International Centre of Insect Physiology and Ecology (*icipe*)	www.icipe.org
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	www.icrisat.org
International Institute of Tropical Agriculture (IITA)	http://www.iita.org/
International Potato Center	www.cipotato.org
Kenya Agricultural and Livestock Research Organisation (KARLO)- Food crops research centre Njoro	http://www.kalro.org/food_crops_research_institute
Kenya Plant Health Inspectorate Service (KEPHIS)	http://www.kephis.org/
Mikocheni Agricultural Research Institute, Tanzania	
National Museums of Kenya (NMK)	www.museums.or.ke
Sokoine University of Agriculture, Tanzania	
Swedish University of Agricultural Sciences	

3.7.1 Coordination, consultation, and communication between stakeholders in the agricultural sector with regard to pest diagnostic services

This survey revealed that in Kenya there is limited coordination and networks between the laboratories involved in pests diagnostics. This study recommends that collaboration should be established and existing network have to be strengthen. Strengthening national laboratories for diagnostics through the development of sustainable collaboration and networks is crucial to assist farmers in crop protection decision-making. It also helps to guide research investments in plant disease management, to ensure food safety and support phyto-sanitary efforts for export crops.

As the survey noticed, the development of a national diagnostic network should be based on the following points.

a) Given the constraints to adopt modern plant diagnostics in Kenya, networking is highly desirable means of sharing scarce resources, expertise and knowledge about the presence and movement of pests and pathogens.
b) There is no single laboratory that provides the range of tests and services needed to serve the nation. There is inconsistent attempts by the current system that duplicate the services in some areas, while no services in others.

c) Mostly, the resources devoted to diagnostics coming from the public sector are limited hence it is not feasible to duplicate the specialists and services embracing every discipline and every plant health laboratory services in Kenya.

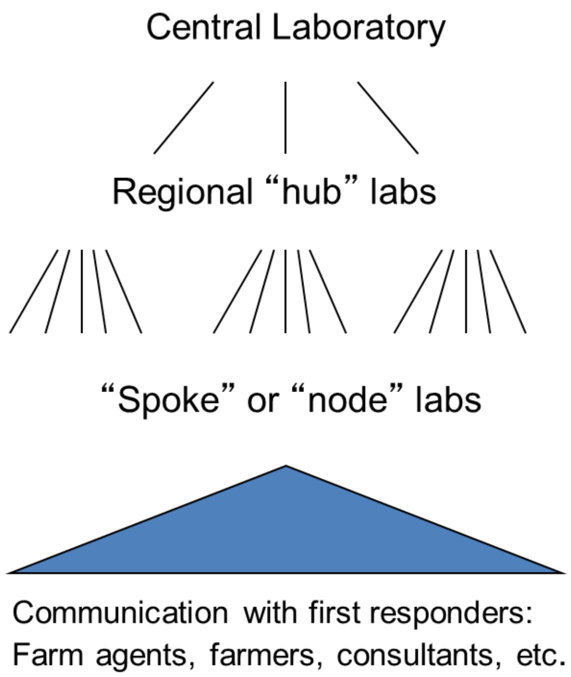
3.7.2 Mechanisms for networking the laboratories

The two options described below can be adopted network establishments in Kenya

i. Networking the existing capability

This option entails linking existing laboratories into a formal network and establishing the network with key laboratories upgraded to a national standard. This would allow each laboratory to maintain its role in diagnostics and to provide services for appropriate pest diagnosis within or between laboratories.

To achieve this stakeholders from all pests and disease diagnostic labs should nominate a central lab that will be responsible to coordinate diagnostic activities across all other labs within the network. The central lab obtains information from regional labs that represents the "node" labs. The Node labs could be constituent of the regional labs. Similarly, information is channelled through the same system. This system could reduce the possibility for unnecessary duplication of services. Secondly maintain expertise in particular disciplines and labs benefits from the expertise and technology available in other laboratories.



Key

- Central laboratory - may be a center of excellence
- Regional labs - capacity for advanced diagnostics; may be specialized within a country, e.g. for virus diagnostics
- Spoke or node labs - at least basic diagnostics

Figure 3.10: Proposed model of organized system of laboratories and personnel communicating with one another and working together

Using this web based network system (Figure 3.10) first detectors can submit digital samples of pests and plant diseases to a clinic or specialists in the network. Specialists or laboratory technicians make a diagnosis based on the digital samples. The diagnostic network should also allow specialists and laboratory technicians to invite external experts for the entire world to assist the diagnosis. Eventually pest or disease problem can be quickly addressed or screened. Laboratory results can be submitted along the same channel.

Adoption of the above proposed digital diagnostics may help to overcome problems of limitation in expertise, resources and restrictions on trans-border shipments of live pest and diseased samples. The archived diagnostic database and a lab digital media library can be used for research and educational purposes. Data confidentiality can be achieved by ensuring the web-based interface. It will be protected by password within laboratories in the network, and security is maintained between diagnostician and sample submitter.

ii. Networking with specific national responsibilities for pest diagnostic

This option entails further development of the network concept. Certain laboratories would be recognised as diagnostic centres for certain agricultural pests. These laboratories would have national responsibilities for: development of standardised protocols; training (diagnosticians and scientists); and providing diagnostic support to aid incursion management.

It should be recognised that both options would require a commitment to manage the network. The first option requires effective communication between the laboratories, a commitment to developing a standard based approach and associated national training responsibilities.

The second option would also need a higher level of national management which would include the on-going assignment and management of specific national responsibilities in diagnostics, the management of budgets to enable laboratories to deliver diagnostic services, and the development of a national communication strategy.

In both of the above options, the concept of mobile diagnostic centres could be explored to cover problems of expertise limitations that is not immediately available. Urgent request for expertise and equipment could be transferred to concerned laboratories for further implementations. This may make the second option more attractive.

4. MAJOR FINDINGS

a) Laboratories that offer agricultural pests and diseases identification services are: Egerton University, i*cipe,* KARLO-Njoro, KARLO-Kitale, KARLO-Tigoni and National Museums of Kenya (NMK) and University of Nairobi (UoN)
b) KARLO-Njoro, KARLO-Kitale and National Museums of Kenya (NMK) and i*cipe* are institutions participating in maize pest and diseases diagnosis
c) Provision of training for farmers (87.5%), technology transfer (37.5%), funding projects (25%), providing accreditation service (25%) and availability of skilled personnel (37.5%) are major strengths of all surveyed labs.
d) Underperformance of the laboratories assessed were linked to; lack of funding from donors and government (75%), lack of equipment, supplies and reference materials (50%) that cope up changes in technology. Regarding human resource capacity, there are gaps in skilled personnel, understaffing and on-job trainings for personnel involved in pest diagnostics. These impediments hamper the ability of agricultural pest diagnosticians in Kenya to provide basic services and further to document the presence of dangerous pathogens and pests within their borders

e) Suggested opportunities laboratories can capitalize for growth and profit were; embracing new technology (75%), networking among the stakeholder labs (87.5%), new funding programs (62.5%), establishment of databases (62.5%) and on-job trainings for diagnosticians (87.5%).
f) Of laboratories surveyed, only 62.5% relied on biochemical techniques for routine diagnosis while 37.5% used molecular techniques.
g) The survey showed only KEPHIS, KARLO-Food crops research centre- Njoro and *icipe* research institutes are the only facilities that offer the full range of biochemical and molecular tests for pests and diseases.

h) Documented procedures for identifying exotic pests and diseases are generally not available, and many laboratories have limited capabilities to identify exotic insect pests and plant pathogens;

i) Only two institutions that is KEPHIS and National Museums of Kenya (NMK) laboratories are ISO-certified for agricultural pest's diagnostics

j) There are no programed trainings for the diagnosticians (63.9%) and human resources personnel in certain disciplines especially weed science, nematology and virology in most laboratories were insufficient e.g *icipe*, KARLO-Kitale and KARLO-Tigoni

k) Although the resources devoted to pest diagnostics are limited, these services are not well coordinate across Kenya to deliver relevant outputs at national level. Lack of management and operational strategies were identified as the limiting factor for developing these networks with common vision (57.1%).

l) There are no pest database that could facilitate diagnosis of the agricultural pests in Kenya.

5. RECOMMENDATIONS

The plant health laboratories and stakeholders should:

a) Stakeholders should source for funds from various organisations and the government to upscale the infrastructure and equipment's required for molecular techniques.

b) Stakeholders should develop capacity for the use of traditional and modern diagnostic tools and technologies through advanced and frequent training programs for the personnel involved in pests diagnosis.

c) Stakeholders should encourage staff to specialise in such fields as taxonomy, nematology, weed science and virology

d) A succession planning for the diagnosticians should be developed and agreed upon by the specific laboratories, recruit more personnel with right qualifications and skills

e) Seek to have their laboratories accredited for agricultural pests diagnosis

f) The laboratories should harmonize laboratory diagnostic protocols within the region and across the borders.

g) Develop a strategic plan to establish a national network of diagnostic laboratories within a quality assurance (QA) framework.

Develop and introduce a distance diagnostics and data management system to overcome problems of limited expertise resources and restrictions on trans-border shipments of live pests and disease infected plants samples.

6. REFERENCES

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