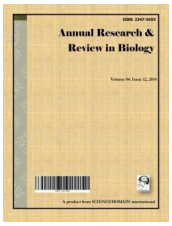

Annual Research & Review in Biology

15(6): 1-12, 2017; Article no.ARRB.34167
ISSN: 2347-565X, NLM ID: 101632869

Emergence of Bio/Agro-Terrorism in Kenya

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2017/34167
Editor(s):
(1) Isaac Oluseun Adejumo, Department of Animal Science, Federal University Gashu'a, Nigeria.
(2) Manikant Tripathi, Centre of Excellence, DST-FIST Sponsored Department of Microbiology, Dr. Ram Manohar Lohia Avadh University, Faizabad, India.
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(6) N. K. Udaya Prakash, Vels University, India.
Complete Peer review History: http://www.sciencedomain.org/review-history/20608

Review Article

Received 17th May 2017
Accepted 18th August 2017
Published 22nd August 2017

ABSTRACT

The growing use of biological toxins, biotechnology and bio-engineering may have, by commensurate measure, contributed to bio-terrorism under what is called agro/bio-terrorism**.** Agro-products finally end up on the tables as food or on the shelves as medicine, and thus any form of their contamination by agro-terrorism will be a huge blow to food, pharmaceutical and medical sectors. This study explores emergence of agro/bio-terrorism in Kenya. Growing threats of terrorism lead the Government to legislate the Anti-terrorism Act of 2012. The act is expected to guard against the occurrence of agro-terrorism that can disrupt the food supply system of Kenyan population through "malicious use of plant or animal pathogens that can cause devastating diseases in the agricultural sector. In the past years, Kenya has suffered a number of epidemic plant and animal disease attacks that mimic agro-terrorism. These include Coffee Berry Disease of 1980s, Rift Valley Fever, Necrotic Lethal Maize Mosaic Virus among others. The methods known for execution of agro-terrorism include dissemination of pathogens in the fields by business competitors, movement

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of plant and animal material during strives and through food and seed imports. The current advances in genetic engineering of various microorganisms have produced very dangerous microorganisms that are classified among the group of weapons of mass destruction. The Government of Kenya has put in place strong regulatory bodies such as Kenya Plant Health Inspectorate Service, Kenya Medical Research Institute and Directorate of Veterinary services that can advise against dangers of agro-terrorism. However, these agencies will still need to be empowered to increase their responsiveness to any form of danger from agro-terrorism.

Keywords: Bio/Agro-terrorism; biosecurity; dual-use organisms; agriculture.

1. INTRODUCTION

Kenya has been a target to terrorism several times since August 7th, 1998 Nairobi bomb blast, which took 213 lives and injured 4,500 people [1]. Terrorism is now a global problem that goes beyond territorial borders and uses diverse weaponry. Among the types of weaponry used include the bio-weapons. A biological weapon is a weapon system that intentionally uses bacteria, viruses or bio-toxins to cause death or disease in people, animals or plants [2-5]. Between 1936 and 1980, there have been several definitions of terrorism [6] and bio-terrorism which encompasses agro-terrorism. Agro-terrorism poses some great global dangerous risk, and because of this the USA Government has put elaborate strategy to counter it under the docket of Homeland Security. Evidence from information obtained from Afghanistan when Americans raided Al Qaeda caves shows that attack on American Agriculture was one of the items in the documents attained [7]. On the other hand, European Union is developing what it refers to as Anti-Bio threat [8]. Terrorism in this area could depress contribution of agriculture to economy that stood at nearly $68 billion in 2006 in case of American [9]. In developing countries like Kenya it can lead to large scale food insecurity.

Bio-insecurity can result from inadequate phytosanitary and zoosanitary conditions that can endanger human [10,11], animal and plant lives creating fears and leading to trade barriers. This is why FAO uses the terms phytosanitary or zoosanitary and biosecurity interchangeably [12]. Bioterrorism and Agro-terrorism are very closely tied to biosecurity [13]. Just like biosecurity, bioterrorism is increasingly becoming an area of concern because attacks could bring about fear and anxiety among the public [14]. There are many ways of carrying out bioterrorism which include; intentional attacks, natural disasters, disease epidemics, resource scarcities like among pastoralist and political insurgencies among others. The key aim of preparedness against Agro-terrorism will be, firstly to protect human health from potential deliberate threats. Secondly it will enable access to a steady supply of safe food products, and thirdly it will remove the psychological implications engendered by fear of poisoned food.

Scenario where disasters like Tsunami can sweep toxins to people, livestock or food can be as bad as where there is a disease outbreak in an epidemic manner. Likewise, there are scenarios where scarce resource has lead people into war and reactions and mobility disaster occur such as pastoralist attack on ranch owners experienced in Kenya in 2017 (report in daily papers). This was occasioned by prolonged drought leading to drying up of rivers and pastures. In such scenarios cases like animals with zoonotic disease maybe moved from one area to another taking with them lethal pathogens. Also, the pathogens can be easily transmitted through trade and in cases of food donations. It has therefore, become necessary to regulate precious basic goods and services such as provision of food, water, medicines and biofuels among others [15]. This will reduce possible emergence of bio-terrorism.

All these events necessitate strengthening of biosecurity. Situations have been realized where biological agents have been used to sabotage human activities or as antipersonnel weapons. This type of threat is categorized as biosecurity issue [16]. Biosecurity can precisely be defined as ensuring the security of biological materials to prevent theft, illicit use and or release. According to WHO biosafety manual2004, biosecurity involve consideration of physical security, personal security information security, transport security and material security [17]. Any lapse in one of these may lead to a lapse in biosecurity management and exposes a nation to bioterrorism. This leads to the question, “what is Agro-terrorism as a form of bioinsecurity?” This is defined as a deliberate introduction of a disease agent, against livestock, plants or into the food

chain, for purposes of undermining stability, cause diseases and generate fear among customers [18].

2. PREPAREDNESS OF BIOTERRORISM/ AGRO-TERRORISM

Bioterrorism/Agro-terrorism is increasing due to greater use of microorganisms or bio-toxins derived from living organisms to cause death or disease in humans, animals and or plants. Effective bioterrorism has not been weighty in the past, but as the technology advances it is increasingly being recognised as a major risk avenue where terrorist activities could take place. For example, the practicing of mono-cropping leads to venerability of crop against diseases and pests [19]. However, use of genetic engineering provides some resistance to certain pests and diseases. Kenya has experienced some epidemic disease outbreaks in human and agriculture that could be an indication of bio-terrorism [20]. In the past biological weapons have been used by many countries including USA, former Union of Soviet Socialist Republics (USSR), Britain and even Japan [21,22,23]. Between 1932 and 1945, in the project called dehumanized logs (*muruta*), Japanese doctors infected Chinese (while still alive) with anthrax, plague and cholera causing bacteria [24]. Britain used small pox against Native Americans during 1763, Pontiac Rebellion (Indian Wars) [25], in 1942 former USSR is suspected to have used tularemia against German troops and USA army is suspected to have sprayed pathogens in the air to test their military effectiveness [26]. Between 1960s and 1980s USA had huge stockpiles of Biological weapons.

During the cold war use of biological weapons, whether by accident or intentional, was noticed in Soviet Union [27]. Under 1972 convention United Kingdom, United States of America and Soviet Union were the states permitted to have custody of the Biological weapons [28]. This gave Iraqis the courage to develop their own, which attracted the attention of United Nations. In 1991, the United Nations Special Commission (UNSCOM) was established to investigate it and it revealed that Iraqis had possession of Botulinum toxin and *Bacillus anthracis* [29,30]. Over the years a variety of microbial pathogens have been used in various acts bordering terrorism. French Republic used *Shigella dysenteriae* to fight the Prussian troops 1792 and in Napoleonic wars, while Germans tried glanders (*Burkholderia mallei*) against the USA and French soldiers in Second World War. *Salmonella*, bacteria and virus seem to be the commonly used biotoxins. Among the bacteria and bacterial products used include; *Bacillus anthracis*, botulinum toxin, *Yersinia pestis* and *Francisella tularensis*, while viral attacks involve smallpox and viruses of hemorrhagic fever such as filoviridae, are naviridae and bunyaviridae [31]. Also, *Burkholderia pseudomallei* that causes melioidosis [32], Staphylococcal enterotoxin B, *Bacillus mallei* and *Bacillus pseudomallei* are among the most commonly used microorganisms [33,34].

The consequences of Bio/Agro-terrorism can be severe and deadly. For this reason, it is important for Kenya and other developing countries to observe the following measures (i) surveillance and strategy to detect and give alert in case of critical outbreaks and (ii) well equipped laboratory for rapid biological diagnostic. In addition (i) availability of pharmaceutical products for prevention and therapeutic, (ii) medical management for victims and good quarantine measures, (iii) training courses on handling of victims of Bio/Agro-terrorism attacks and (iv) research in this critical area are needed.

Biological weapons are considered to be weapons of mass destruction [35,36]. The weapon are gaining preference with terrorist because they are invisible, silent, odourless, tasteless and inexpensive to produce compared to others like nuclear warheads. Act of terrorism needs to be differentiated from bio-warfare where the later occurs in situation where there is a declared war and the former is an ambush. The only common thing is that both use biological weapons. Terrorists use biological weapons but in a non-conventional manner like use of letters to disseminate dangerous materials like anthrax spores. Since bio-terrorism is a broad area, discussions in this paper will be focused on Agro-terrorism.

3. SIGNIFICANCE OF AGRO PRODUCTS TO TERRORIST

Agro-products end up on the table as food or on the shelves as medicine. Thus, any form of Agro-terrorism will be a huge blow to food, pharmaceutical and medical sectors. In fact, Agro-terrorism or Agri-terrorism is defined as a malicious attempt to disrupt or destroy the agricultural industry and/or food supply system of a population through "malicious use of plant or animal pathogens to cause devastating disease

in the agricultural sector"[37]. Countries that are dependent on Agriculture for their gross domestic product (GDP) are likely to be major victims of Agro-terrorism [38]. Due to this, a form of Threat, Vulnerability, and Consequence (TVC) Analysis [39] is needed. Vulnerability of Kenya to terrorism and for both developed and developing countries is dependent on the following; 1) the proliferation of terrorists like Al-Qaeda and Al-Shabaab groups in Somali that borders Kenya; 2) the dependence of a significant portion of the Kenyan economy on agricultural exports and imports; and 3) use of large scale agricultural plantations like coffee. Developing countries including Kenya may suffer more from Agro-terrorism due to the following: 1) lack of capacity to monitor potential emergence of agricultural diseases and pests; 2) lack of expertise in risk assessment practice and decision-making; 3) poor existing biosecurity measures; and 4) fragile economies that are mainly dependent on Agriculture.

Growing Biotechnology and Bio-Engineering is good for economy but, it may have by commensurate measure contributed to bio-terrorism. This has led to stringent measures to deal with it especially in developed economies like the USA. This combined with traditional bio-terrorism aggravates the problem. In USA the spinach and lettuce disasters that was traced to tomatoes contaminated with Salmonella, which affected almost 200 people in 21 states [40] and *E. coli* outbreak associated with shredded lettuce [41] respectively lead to economic loss of up to $50- 100 million.

4. USE OF AGRICULTURAL BIO-WEAPONS

Agricultural bioweapons surveys aiming at agricultural production have been conducted by nations/states and also by sub-states and organizations throughout history. According to Congressional Research Service (CRS) [42], in the 20th century a number of states including Canada, France, Germany, Iraq, Japan, South Africa, United Kingdom, United States and the former USSR had documented agricultural bioweapons programs (26). Despite extensive research biological weapons have rarely been used against crops or livestock, especially by state actors. Examples of state actors who have used biological weapons against agriculture include Germany's use of glanders against Allied horses and mules in World War I, the alleged use of anthrax and rinderpest by Japan in World War II, and the alleged use of glanders by Soviet Union as reported in Congressional Research Service [42]. Although individuals or sub-state groups have used bioweapons against agricultural or food targets, only a few can be considered terrorism in nature. In 1952, the Mau Mau (an insurgent organization in Kenya) killed 33 heads of cattle at a mission station using African milk bush (a local plant toxin) [42]. In 1984, the Rajneeshee cult spread salmonella in salad bars at Oregon restaurants to influence a local election [43]. Chemical weapons have been used somewhat more commonly against agricultural targets. During the Vietnam War the U.S. used Agent-Orange to destroy foliage that affected some crops. Among possible terrorist events recorded, chemical attacks against agricultural targets include a 1997 attack by Israeli settlers who sprayed pesticides on grapevines in two Palestinian villages destroying up to 17,000 metric tons of grapes. The Arab Revolutionary Council was reported to have poisoned Israeli oranges with mercury in 1978. This resulted to injury of at least 12 people and reduced Israel orange exports by 40% [44]. Terrorist groups in states surrounding Kenya can lead to a similar terrorist act if not checked.

Zoonotic diseases are those diseases that are easily transmitted from animal to human. Thus, they can potentially be used on war head carriers. This is because they kill the animal and if not well handled they can get up to the food plate served on the table. This means that even those people who are not animal handlers get infected. Also, sometime weapons targeting plants could be loaded with human pathogens [45]. This could create panic and cripple agricultural industries. The terrorist main objective is to cause destruction of livestock and crops in situation where it is difficult to cause mass human casualties without harming the attackers. The disease causing agents targeting agricultural sector have the advantage of posing little threat to the people developing them and their use is less likely to lead to strong reprisals or loss of public support of the users but transfer the blame to a Government. They are therefore, attractive as a terrorist's weapon. During World War II the government of the United Kingdom considered feeding linseed cakes containing anthrax to German cows and infecting Japan's rice crops with a fungus, but instead chose to use more conventional weapons with more immediate effects [5].

5. POTENTIAL AGRO-TERRORISM PATHOGENS

5.1 Agro-terrorism Pathogens

Agro-terrorism pathogens cause diseases to livestock, crops and even human leading to panic among the citizen. These pathogens includes Ebola virus; Anthrax caused (*Bacillus anthracis*); Plague bacterium (*Yersinia pestis)*; Tularaemia bacterium (*Francisella tularensis*); Fever causing bacterium (*Coxiella burnetii)*; Influenza virus; Small pox virus; Viral encephalitis viruses which are transmitted by mosquitoes; Virus associated with haemorrhagic fevers; Botulinum toxin bacterium; *Staphylococcus aureus* that produce staphylococcal enterotoxin B among others [46,47]. Ebola being a haemorrhagic viral diseases [48,49] is one of the viruses that are considered potentially usable in grade A bioterrorism agents.

5.2 Attempts to Use Terrorism Act

In 1984, AumShinrikyo a sect in Japan that was assisted by well-trained scientist attempted to use pathogen test against innocent society [50]; The Rajneeshee salmonella is another case in Dallas Oregon state where Bhagwan Shree Rajneesh [51,52] tried to put disease causing bacteria in the salad bars of ten local restaurants over a three-week period in September of the year 1984. There are fears that some cases like these could occur in Kenya, but unnoticed due to lack ability to distinguish between terrorism natural occurrences. According to a story published in Star Newspaper (Kenya) on June 22, 2017, about fifty people contracted cholera while attending a health conference in Nairobi. This needs to be investigated to rule out an intentional spread of cholera causing bacterium.

6. BIOTERRORISM - THE THREAT AND THE REALITIES

There are a number of indicators that show potential occurrence of bioterrorism globally including Kenya. Some of the indictors pointing to these scenarios are as described below. Firstly, there are a number of unemployed or underpaid scientists who used to work on the biological weapons programs of the Soviet Union, Iraq and South Africa. Some of them might be tempted to sell their knowledge or expertise to country willing to buy them. Also, it is rumoured that some of Russia's secret criminal gangs possess biological agents which were developed in the Soviet bioweapons program [53]. Secondly, terrorist groups might now be competing for attention and seeking more dramatic methods to be recognized. Thirdly, biological weapons could be attractive to terrorists who wish to remain anonymous and to appear as 'enigmatic, unseen and unknown assailants' [54]. Kenya has experienced enough terror attacks since Nairobi bombing of Norfolk Hotel in 1980; United States embassy bombings in1998; 2002 Kikambala Hotel bombing and Arkia Airlines missile attack in Mombasa; 2012 Al-Shabaab attacks; 2013 Westgate Mall shooting 2014; Mpeketoni attacks and 2015 Garissa University College attack. These are enough to make the country alert of any other attack including Agro-terrorism.

7. ANTHRAX/SMALLPOX-A CASE OF AGRO-TERRORISM / BIOTERRORISM

The Anthrax bacterium has been most popular in both biological weapons programs and terrorist attempts (sometime hoaxes) [55]. It is fairly easy to grow in a laboratory, sturdy and relatively easy to disseminate in spore form and has a high fatality rate. Smallpox is also easy to produce and stable and it has an added advantage of being transmissible from person-to-person, but it has become increasingly difficult to acquire the virus. However, Anthrax disease causing bacterium (*Bacillus anthracis)* is much easier to culture in the laboratory and package spores for terror attack. The risk factor is that the bacterium is microscopic and cannot be recognised easily like an ordinary weapon (such as grenades and other types of weapon of mass destruction) yet its effects are disastrous. According to American centre for disease control (CDC), recognition becomes obvious after its effective incubation period of 5-7days [56]. Besides, the forms of exposure that exists are cutaneous (skin exposure), gastrointestinal (entering through the digestive system) and inhalation which are the routine forms of handling pets and foods. This makes it easy to transmit by handling common animals and foods.

Bacteria are biological agents that kill people and livestock [55]. Anthrax causing bacterium is one of the most likely agents to be used because of its virulence. Its spores are easily found in nature, can be produced in a laboratory and can last for a long time in the environment. Anthrax can be released quietly and without anyone knowing and thus makes a good silent weapon.

The microscopic spores could be put into powders, sprays, food and water. Their nature is that they are too small and you may not be able to see, smell or taste them. Besides, the spores have been used as a weapon before and thus there are some people or laboratories that have good skills of producing it. According to article appearing in standard newspaper by Thumbi Mwangi of May 14th 2016, Kenya needs to enhance her surveillance to reduce risk against anthrax bioterrorism attack.

8. AGRO-TERRORISM ENTRY POINTS

Attack can be launched directly to animals or plants, however, it can also include the following systems a) Transportation b) Water supplies; c) Grain elevators and other storage facilities; d) Producers including farmers and their farm workers; e) Restaurants and food handlers; f) Grocery stores; g) Food and agriculture research laboratories and packing and food processing facilities among others. After 1998 USA terrorist attack the total cost of the anthrax threats was estimated to be over $1billion. This included decontamination of various buildings, treatment and procurement of irradiation equipment for irradiating mail suspected to contain anthrax spores. This was exclusive of the indirect cost like clean up and response to false alarms over "white powder" of household origin and lost productivity associated with resultant work stoppages [57].

9. THE THREAT-VULNERABILITY-CONSEQUENCES (TVC) ANALYSIS FRAMEWORK

Some preparedness through a form of risk assessment is necessary to forestall any possibility of Agro-terrorism attack in Kenya. Risk is defined as function of interactive effects of s_i, p_i, x_i where s_i is the risk scenario and each s_i has a probability p_i of occurring and a consequence x_i if it occurs [58,59]. Terrorism risk may be thought of as a function of the threat level, vulnerability to the threat and consequence from the terrorist action [36]. For example, terrorist attack on a food factory; the risk estimate could refer to an attack by terrorists against food factory using a particular disease pathogen or toxin. The threat would then be an estimate of the terrorists' priority for an attack against the available alternatives. Vulnerability could be estimated as likelihood of post interception and the consequences would be the impact of the disease.

10. AGRO-TERRORISM - THREATS AND PREPAREDNESS

Agro-terrorism is real and thus preparedness is a must and this includes;

i) Development of Technologies to counter bioterrorism. For instance, by-products of the production of castor oil that is classified by the Centre for Disease Control (CDC) as a Class B bioterrorism agent has high level of ricin. Preparedness to this is to use Biotechnology to produce transgenic castor oil with low level of ricin [60].

ii) Improve on Biosecurity: According to Food and Agriculture Organization (FAO) of the United Nations the term "biosecurity" is inclusive of phytosanitary and zoosanitary measures and Kenya will need to apply it in Food and Agricultural regulatory systems.

iii) Regional and international cooperation: Greater global cooperation in the form of financial aid and technical assistance can help Kenya to build capacity in biosecurity and ability to cope, especially with issues caused by Al-Qaeda and Al-Shabaab terrorist in the neighbouring Somali and Sudan. Kenya needs to be ready for many emerging specific threats of Agro-terrorism as well as the more general spread of plant and animal pests and diseases.

iv) Enhance surveillance and restriction of biotechnologies of "dual-use" to useful activities. Bio-engineering has useful aspect but it has disastrous aspects too. Example, anthrax bacteria can be used in research as well as for terrorism, thus the bacteria needs to be kept under strict control.

v) Strengthen bioterrorism attack monitoring systems to enable early detection and reduce the risks.

vi) Strengthen animal disease immunization and breeding of disease and pest resistant breeds and plant varieties.

vii) Kenya needs to increase biodefence research. This is research that focuses on a number of areas, including vaccine development, treatment of disease and rapid detection of biological, and restriction of biological toxins. This will include research on biological detectors such as Biological Integrated Detection System (BIDS).

viii) Enhance Global epidemiological disease surveillance: In April 2017 Kenya

experienced a serious Arm worm outbreak that severely affected crop yields. The country now, needs to establish an agency to investigate unusual disease and pest outbreaks to determine if outbreak is through accidental release of biological agents or through a deliberate use of a biological weapon.

11. BIOTECHNOLOGY AND AGRO-TERRORISM

Biotechnology provides very fertile ground for agro-terrorism. For example, the virus and bacteria that are used to make vaccine could as well be used for terror activities. Besides, the increase in bacterial, viral and fungal engineering can lead to more virulent plant and animal pathogens that are difficult to control. Inclusion of strong promoters like that of Tobacco Mosaic virus in various gene cloning vectors [61] may have increased the virulence of many potential pathogens.

12. DUAL USE ORGANISMS

Deadly Virus and bacterium have been bio-engineered to produce various vaccines. Vaccines like Bacillus Calmette-Guerin (BCG) rabies and anthrax among others are made of various viruses or bacteria in attenuated or non-living forms. Such microbes are highly dangerous yet highly useful [62,63]. Strict screening is needed so as to regulate people who handle them.

13. KENYA'S BIOTERRORISM/AGRO-TERRORISM SCENARIO

In Kenya the law dealing with terrorism include, "The Prevention of Terrorism Act, No. 30 of 2012" [64]. The Act outlaws use of destructive materials including that of biological form. The government has established regulatory bodies that can prevent action of Agro-terrorism as they carry out their other mandate. These include; Directorate of Veterinary Services, Kenya Plant Health inspectorate Service (KEPHIS), National Biosafety Authority and other related bodies that need to enhance their surveillance methods so as to detect early forms of Agro-terrorism. It is always good to be aware of manifestations of a bio-terrorism attack. According to Vapnek and Manzella [65] a biological attack is suspected if the following are noticed; A disease appears that does not occur naturally in that area or there are unusual combinations of diseases in same animal or plant fields, large numbers of unusual infections or casualties, data on disease epidemiology suggest that the outbreak originated at a single source and the disease has an unusual apparent route of transmission. The following may also indicate possibility of terrorism; in cases where zoonotic diseases like Rift valley fever morbidity and mortality rates are extra ordinary high, the casualties occur within a limited geographical area, there are low infection rates among people who work within closed ventilation systems, plants and animals in the area are also succumbing to the disease and the disease is normally vector-borne but the natural vector is not found in the area. Kenya has suffered many incidences in the so called emerging diseases. Among them include; Rift Valley fever, Aflatoxin, Maize necrotic lethal virus diseases and Citrus greening disease among others.

13.1 Rift Valley Fever

This is characterized by high mortality rates in young animals and abortions in pregnant ruminants. In addition, epizoonotics are often accompanied by human disease. This makes it a good candidate for use in terrorist. In the current history, the 2006–2007 outbreak was the most extensive in cattle, sheep, goats and camels affecting thousands of animals across Kenya [10]. About 700human lost their lives due to infections and an estimated economic loss of US$32 million [66]. This could qualify in description given for Agro-terrorism, only that confirmation needs to be done to verify if it was intentional or natural outbreak. The outbreak led to closure of abattoirs in the affected areas [67].

13.2 Aflatoxins

It is produced in minute quantities, but its potency, prevalence and the ease with which it can penetrate into the farmers' fields and storage areas makes it highly carcinogenic metabolite [68,69]. Mycotoxins can be used as chemical warfare agents [70,71,72]. According to Cupp et al. [11], there is considerable evidence that Iraqi scientists developed aflatoxins as part of their bioweapons program during the 1980s. Toxigenic strains of *Aspergillus flavus* and *Aspergillus parasiticus* were cultured and aflatoxins were extracted to produce over 2,300liters of concentrated toxin [72]. The majority of this aflatoxin was used to fill warheads. Kenya has experienced incidences of

aflatoxin poisoning in 2004 leading to the death of 125 people due to consumption of aflatoxin contaminated maize [73,74]. The most recent endemic in the former Eastern province of Kenya [75] needs further scrutiny to identify if it could be, at one time an act of terrorism.

13.3 Viral Uses in Agro-terrorism

Viral infections have been used by terrorists in both plants and animals with the aim of causing food shortages and create national tension. These include Rift Valley Fever virus [76] wheat rust, rice blast, tobacco mosaic virus, brown leaf rust and rye blast [77]. Viral infection is suspected to have been used in some African and Asian countries to cause total financial and partial food shortage for human and livelihood. One of the challenging diseases that have been experienced in Kenya is maize necrotic lethal (MNL) viral disease [78,79]. It is not known if the MNL viral disease is any form of terrorism, but what is obvious is that financial loss is great whenever there is an outbreak.

13.4 Other Fungal and Pest Diseases

Fungus called *Colletotrichum kahawae* cause coffee berry disease that can lead to near crop failure [80,81] and can be a potential Agro-terrorist weapon in coffee industry. It can infect leaves, stems, bark, twigs of the coffee plant and immature or green berries too. When occurring on the immature green berry this disease is known as brown blight and it can lead to major crop lose [82]. Coffee industry is full of trade rivalry and it is not known if the disease could be intentionally spread through Agro-tourism or as a result of competition in trade. For many years Kenyans have been infested with jiggers and the problem is not completely contained yet. The problem is severe in regions of central Kenya [83]. The magnitude fits the definition of bio-terrorism.

14. CONCLUSION

Kenya has experienced a number of terrorism activities starting from 1952 “Mau Mau” attack of cattle to the 2015 Garissa University attack. Among them, the 1952 was confirmed to have been a terrorist activity. However, there have been some serious epidemic diseases like the Rift Valley Fever of 1997 that need to be investigated to confirm if there was an act of terrorism. Also, there is the incidence of necrotic Lethal Maize Mosaic Virus, which nearly crippled Kenya’s maize production in 2012. All these incidents fit well within the definition of Agro-terrorism given the damage they have inflicted onto the farmer. Therefore, agro-terrorism cannot be ignored in Kenya. Given this experience, the country needs to put in place a strong Agro-terrorism surveillance mechanism to avert any potential danger. At the same time a strong biodefence research is needed so as to identify mitigation strategies in case of Agro-terrorism attack.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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DOI:10.1186/s40794-015-0015-4.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/20608