Major Signs and Symptoms Caused by Biotic and Abiotic Agents on Plants in the Tropical Africa

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Abstract: ***There exist two classes of plant diseases; those caused by living microbes also termed biotic or infectious and those caused by non-living agents also referred to as abiotic or non-infectious and include damage from air pollution, nutritional deficiencies or toxicities. Diseases, regardless of class exacerbate crop loss and consequently contribute to food insufficiency in tropical Africa. In order to identify and develop strategies to combat the disease-causal agents (DiCA), it is necessary to understand and appropriately differentiate the signs and/or symptoms (SoS) to avoid wrong or inappropriate use of resources including reagents, time and equipment on wrong disease-causal targets. It is most obvious that biotic DiCA populations are variable in genotype, time and space, and can evolve, but a number of SoS are likely to be evenly or slightly unevenly the same. Thus, this review discusses basic characteristic SoS caused by the DiCA in the tropical Africa. The region has been focused due to existence of different interactive factors in the plant-disease environments all of which cause confusion in the differentiation of the SoS. This information will be used by agricultural extension staffs and crop producers in taking ideal steps towards plant disease control, and lower and higher career phyto-pathologists in decidingand justifying proper detection, characterization and identification methods of responsible biotic or abiotic factors.***

Keywords: Symptoms, Signs, Biotic agents, Abiotic agents

1. Introduction

Plant diseases have been reported to destroy food crops leaving at least 800 million people in inadequately food situation globally (Strange and Scott, 2005). There are two classes of plant diseases those caused by living microbes also termed biotic or infectious and those caused by non-living agents also referred to as abiotic or non-infectious or disorders and include damage from air pollution, nutritional deficiencies or toxicities (Agrios 2005, Mara et al., 2012). These diseases, whether biotic or abiotic produce some visible effect on the plant also referred as symptoms which can include a detectable change in color, shape or function of the plant as it responds to the disease-causal agent (DiCA). With exception of abiotic diseases, some biotic DiCA can produce some physical evidence of their presence on planttermed "signs" such as fruiting bodies formed by fungal pathogens andthick exudates emerging infected areas in case of some bacterial pathogens (Agrios, 2005; Pernezn et al., 2014).

2. Symptoms and Signs Resulting from Disease Causing Biotic Agents

2.1 Phytopathogenic Fungi

Phytopathogenic fungi like most fungi are multi-celled microorganisms and cause about 85% of plant diseases (Pernezn et al., 2014). They can be dispersed by wind, splash water and infected tools, and enters plant throughnatural openings such asstomata, or through wounds and can penetrate directly through the plant's cuticle. Major DiCA produced by fungi are as described in the sections below

2.1.1Necrosis

Necrosis involves death and destruction of plant tissues resulting from reaction of host plant with the pathogen. In this interaction, the infect cell and tissue die thus form necrotic portions on the plant tissue (Watkins et al., 1996). During the infection process, the fungal pathogen secrets enzymescalled effector proteins which kill the tissue and make it available for fungalnutrient uptake, this is however different from hypersensitive response (HR) which is programmed defense strategy of plant against pathogens. Necrotic symptoms can be either localized i.e.symptom at the point of infection with host or systemic i.e. symptom spreading though out the foliage, or stem, or entire plant(Singh, 2007).

2.1.2 Leaf Spots

Leaf spot symptoms vary with the plant host and the causal agent (Anderson et al., 2004 &Douglas, 2012). Typical leaf spots usually have fairly defined margins and brown, black, tan, or reddish centers. Spots vary from pin-head to several centimeters in diameter and can coalesce to encompass entire leaves (Kirk & Wharton, 2012). Some spots are circular and others are irregular in shape, some are raised, some spots drop out and give the leaf a shot-holed appearance, and some spots have distinct yellow haloes. Heavily infected leaves turn yellow and brown, shrivel, and drop prematurely (Andrew & Liu, 2016). The typical fungal leaf spot will have a "bulls-eye-like" appearance consisting of roughly concentric rings that may display zones of different colors such as yellow, red or purple, and will often have a tan center (Brown, Kebede, & Nicholls, 2009). As the spots develop, they are not restricted by the leaf veins as can be the case in bacterial leaf spots. Fungal leaf spots will usually have a dry texture (Menge et al., 2013).

2.1.3 Blights

Blights involve rapid generalized browning and death of leaves, floral organs, branches andstems. The blights can begin as light brown, irregular spots surrounded by yellow borders that develop from the tip of the leaves and gradually progress backwards (Dixon, 1981). At advanced stage the lesions become large stating from either lower or top leaves and increase in number eventually complete burning of the foliage(CIMMYT, 2004).

2.1.4 Blasts

Blasts involve lesions which can begin as whitish, grayish or bluish spots which expand greatly to then kill tissues. One of good examples is the rice blast caused by *Pyriculariaoryzae*. The lesions enlarge quickly under moist, warm condition to either oval spots with gray or white centers and narrow brown or reddish brown borders (Grahame, 2014). Necrotic lesions are visible on the leaves, nodes, and at the base of heads (in case of rice). The lesions usually become diamond shaped or linear lesions with pointed ends. As lesions mature their centers often appear cottony on the surface and dark bluish due to the production of conidia (spores). The shape, colour and size of leaf lesions may vary in time due to the age of plant or cultivar. In the case of severe or multiple infections, lesions may coalesce covering most of the leaf blades (Burrows et al., 2013).

2.1.5 Damping Off

Damping off occurs following fungal infection on seeds or seedlings. When infected with damping off –causing fungi, seeds may fail to germinate and if it does, it falls over and die (Howell, 1980). If the stem is examined at the soil line, damping off is characterized by a discolored, "pinched in" appearance symptom on the stem. The most common damping off-causing fungi are*Pythium*sp., *Fusarium* spp, *Phytophthora*sp.and*Rhizoctonia*sp (Kevin, 2008).

2.1.6 Scab

Scabs are localized lesions which are due to the slightly raised and cracked outer layer of the fruits, leaves or tubers (Singh, 2007). Some examples include apple scab disease caused by *Venturiainaequalis* on apple and Pear Scab caused by *V. pirina* on pear. Infection by these fungi usually result in a roughened, crust-like area on the surface of the host (Butt et al., 2016).

2.1.7 Root Rots

Root rots harm plants by stressing or killing root systems. The common soil- inhabiting fungi that cause root rots include *Fusarium sp*. and *Rhizoctonia sp* (Subrahmanyam et al., 1992; Singh, 2007). Root rots are charcterised by darkening, limpness, and mushiness of roots (Green, 2015). Rotted roots may break off easily and due to sloughing off of the cortex, a thread-like root core remains making the entire plant wilt (Rory & Kerstin, 2002; Wharton et al., 2007). Root rots results into yellowing and browning of lower, interior leaves and drop off. The infected plants may be stunted and if roots are damaged, the plant dies (Watkins et al., 1996).

2.1.8 Dieback

Dieback involves progressive death of shoots and twigs generally starting at the tip of the infected plant part. One of common example is shoot diebackof apple (Butt et al., 2016). Dieback can also be caused by bacterial pathogens such as those associated with *Pseudomonas syringae*in tomato,(Kennelly *et al.,* 2007).

2.1.9 Leaf curling

Easily distinguishable symptoms like distortion, discoloration and curling of the leaves due to fungal pathogen (*Taphrina deformans*). In the early stages the leaf show red colouration, thicker and softer then normal mature leaves(Fuentes, 2003). *T. deformans* mostly affect peach by induces cells of infected leaves to multiply rapidly and randomly and enlarge, resulting in deformation and curling. The infected distorted leaf parts are often yellow or red colored. Infected leaves eventually turn brown and fall off. Young infected fruit may also drop prematurely or fruit will show wart-like symptoms when mature. The tree will leaf out again to replace the fallen leaves which can result in significant yield reduction (Claudia, Brent, & Mike, 2011; Gauthier & Morgeson, 2015).

2.1.10 Galls

Galls are enlarged parts of plant organs, usually caused by excessive multiplication or enlargement of plant cells. They may develop on stems, roots or leaves. These are masses of undifferentiated tissue growth, similar to cancerous tumors in people(Pernezny et al., 2014).. Some examples include Camellia Leaf Gall (*Exobasidiumcamelliae*), Plum and Prune Black knot (*Apiosporinamorbosa*), Pine Western Gall Rust (*Peridermiumharknesii*), Clubroot (*Plasmodiophorabrassicae*) enlarged roots that look like clubs or spindles e.g. Clubroot of Crucifers (*Plasmodiophorabrassicae*), Burr Knot of apples caused by environmental and/or genetic factors can be similar to bacterial galls.

2.1.11 Clubroot

Gall formation or distortion take place in the roots giving the appearance of spindle or clubs.Example: *Plasmodiophorabrassicae* cause clubroot of crucifers (Sinha, 1999). Symptoms will vary depending on the growth stage of the crop when infection occurs. Early infection at the seedling stage can result in wilting, stunting and yellowing of canola plants in the late rosette to early podding stage. Such symptoms may be wrongly attributed to heat stress during periods with high temperatures or to other diseases such as blackleg or Fusarium wilt (Murray, 2015).

2.1.12 Gummosis

It is the oozing out (seeping) of the amber coloured exudate from the diseased tissue which may be bark of the stem, leaves or fruits and later sets into solid mass. The plants produce gum/exudates as a defensive mechanism against the entry of pathogen into the host tissues. Different species of *Botryosphaeria* cause gummosis in different plants (Denman et al., 2003).

The infected plants show abundant gum secretion from branches, stem, and main trunk. At the beginning gum appears as a small droplet. However, as the disease progresses, it increases and covers most of the branch and trunk. Under severe conditions, the outer wood of a branch cracks and splits and exudes a yellow to brown, gum-like substance (Halcomb, 2010).

2.2. Phytopathogenic bacteria

Phytopathogenic bacteria are one-celled microorganisms which cause disease in plants (Pernezny et al., 2014). They can be dispersed by water splash, wind, infected tools and in some bacterial diseases such as banana xanthomonas wilt caused by *Xanthomonascampstris*pv*musacearum* of banana, insects such as bees can move the pathogen from one flower to another. Major symptoms produced by pathogenic interaction of the DiCA and host are as described below.

2.2.1 Bacterial wilting

Symptoms starts on a single leaf which suddenly wilts and becomes dull green and dies (Seebold *et al.*, 2014). One of major known bacterium associated with wilt symptoms in plants is the *Ralstoniasolanacearum.* This is the most destructive plant pathogenic bacterium worldwide (Brown & Wilt, 2010; Mansfield et al., 2012). The bacterium is soil-borne and infects plants via wounds, root tips or cracks at the sites of lateral root emergence. The bacterium subsequently colonizes the root cortex, invades the xylem vessels (where it rapidly multiplies) and reaches the stem and aerial parts of the plant through the vascular system (Momol, 2000).

2.2.2 Galls

Galls which also form in some fungal infected plants as previously described can also develop as a result of bacterial infection. Example, an infection of plants by *Agrobacterium*spp(Lacroix & Citovsky, 2013) . In nature, this soil-borne bacterium induces neoplastic growths at wound sites on host plants and severely limits crop growth vigor and yield. The galls are characterized by the development of tumorous overgrowths on roots, crowns, and occasionally trunks and scaffolds (Burr *et al.,* 2004). They are initially soft and smooth, but they turn dark, hard, rough, and woody as they enlarge and age. Mature galls, which may reach more than 10 cm in diameter, often appear gnarled and fissured. Cracking allows secondary decay organisms to enter, leading to the breakdown of gall tissues (Goldberg, 2006).

2.2.3 Bacterial leaf spot

Bacterial leaf spots are common in bacterial infection. They start as water soaked lesions on leaves, blossoms, fruits and stems (Subrahmanyam et al., 2009). The developed spots in some crops such as those in the dicotyledonous group usually have a rotten or fishy order, initially confined between the leaf veins and appear angular (Shaw, 2016). In some cases symptoms and or signs (SoS) of bacterial infestation can be observed, for example, bacterial ooze signs and, a chlorotic halo which surrounds the bacterial lesion in infected leaf. Spots may coalesce causing large areas of necrotic tissue (Jim, 2006; Douglas, 2012).

2.2.4 Bacterial scabs

The appearance of a scab can display the SoS of bacterial infection in plants. Scabs have corklike lesions-pitted surface. The lesions start out as small brownish spots, which enlarge into water soaked circular lesions and develop under warm, dry soil conditions with a soil pH above 5.2 (Wharton *et al.*, 2007). Bacterial scabs primarily infect belowground parts of plants such as potatoes. Example, common scab of potato caused by *Streptomyces scabies* which cause localized scabby lesionson the outer surface of the tuber forming a „corky tissue‟. Pathogens associated with rotting in tubes can gain entrance into the host tissue through these lesions and further degrade the host (Han et al., 2005).

2.2.5 Bacterial canker

Bacterial cankers also can also describe the SoS of bacterial infection primarily by some *Pseudomonas* and *Xanthomonas*spp. Examples are the canker diseases on citrus (Fransico *et al.*, 2007). Canker symptoms can appear on trunks, stems, twigs and branches (Cazorla*et al.*, 2007). In some trees, SoS of bacterial infestation may displayed by gumexudation (gummosis) examples in stone and pome fruit trees (Tisserat, 2004). Cankers can be slightly sunken, dark brown and longer. The cortical tissue of the canker can be orange brown to dark brown(Hansen, 2014; Bush, 2015).

2.2.6 Bacterial soft rots

Some bacterial microbes such as *Erwinia*spp., *Pseudomonas* spp., *and Bacillus spp*and*Clostridium* spp are associated with rots in a number of crops. For example Erwinia soft rot of potatoes (Seebold, 2014) . The symptoms appears as small water-soaked spots on the leaves/tissues and often are surrounded by a yellow halo (Honger, 2004). Those wet rots may have a foul odor. These rot causing microbes are opportunistic, enter through wounds and spreads so rapidly that plants may be completely rotted in 2-3 days (Schwartz & Gent, 2007). Rotting tissue becomes watery and softand bacteria forms a slimy foul smelling oozethat will ooze out of infected tissue (Seebold, 2014).

2.2.7 Bacterial blights

Bacterial blight infection in plants starts as dark green, water soaked spots visible on the underside of the leaf (Valente *et al*, 2015). As spots age they turn dark brown and become visible on the upper surface of the leaf and each spot spreads until restricted by fine leaf veins, causing an uneven angular appearance of spot margins on leaves and may die and drop from the stems (Almeida, 2015). The symptoms may move from the leaves to the stems as the disease progresses, turning the tissue black and causing it to wilt and the stems infection causes girdling of the tissue resulting in the death of shoots and blossoms (Nelson, 2009).

2.3 Virus

Viruses are particles made up of genetic material i.e. ribonucleic acid (RNA) or deoxyribonucleic acid (DNA), which are usually wrapped in a protein coat and using their living hosts to reproduce (Jones, 2013). There is a number of disease symptoms caused by viral infection on plants as described below.

2.3.1 Mottling

Mottling symptoms involves yellowing and/or crinkling of leaves, misshapen leaves and yellow or necrotic rings on leaves or fruits (Pernezny *et al*, 2014). The infected leaves display green or darker mottle and streaks. The infected plants stunts (dwarfs) due to shortened internodes, (Pallas and Garca, 2011).

2.3.2 Mosaic pattern

This is the most commonly visual symptom which is the development of a pattern of light and dark green areas in infected plant parts, (Biswas et al, 2016). It is mottle with a mixture of light and dark green areas on the leaves where uninfected leaves would be uniform in color. Blisters can also be associated with the dark green areas, (Mathews, 2010).

2.3.3 Leaf blistering

Leaf blistering (Al-Ani et al; 2011) is another viral symptom in which characterized by swelling on a plant leaf similar to that on the skin. In tomato crops, blistering infection caused by Tomato blistering mosaic virus, TBMV (Ferrand *et al.*, 2015).

2.3.4 Leaf streaking

Streaks which are minute, pale, circular spots on the lowest exposed portion of the youngest leaves. On disease progresses, newer leaves emerge containing streaks up to several millimeters in length along the leaf veins. They then fused and form narrow, broken, chlorotic stripes, which may extend over the entire length of severely affected leaves (Shepherd *et al.*, 2010). This exemplified by Maize Streak Virus.

2.3.5 Plant stunting

Plant stunting (Schreinemachers *et al.*, 2015)which characterized by the reduction of the size of the leaves, fruits, petioles and internodes e.g., Bean yellow mosaic and Bunchy top of banana.

Normal yellowing in the leaves represent a clearing or yellowing of the veins in younger leaves and later on redding of the leaves. These yellowing symptoms normally found in the diseases caused by Barley yellowdwarf virus and Rice tungro bacilliformvirus(Biswas *et al.*, 2016). This symptom characterized by the turning yellow of plant tissues from green (Kumar and Waliyar, 2007).

2.3.6 Leaf rolling

Another viral symptom is leaf rolling (Randles and Ogle, 1997). It is usually found in upward and thereafter downward of the plant shoot region like in potato caused by Potato leaf roll virus(Biswas *et al.*, 2016). Plants affected become stunted or dwarfed. Leaflets are rolled upwards and inwards while the leaves are often bent downwards (epinasty), stiff, thicker, leathery texture and often have a purple tinge to the venation on the undersurface. Fruit of affected plants, is smaller than normal and dry in texture. Also, advanced infection will not produce fruit (Condé, 2006).

2.3.7 Concentric ringspots

Sometimes a pattern of concentric rings and irregular lines appears on leaves and fruits of infected plants caused by Papaya ring spot virus and Tobacco ring spot virus. They are ringspots and line patterns that range from small circles to multiple concentric rings (like a target pattern) while the lines are randomly run along the leaf surface with normally yellow or light brown in color (Mathews, 2010). The pattern may consist of yellowed tissue (death ofsuperficial layer of cells), giving an etched appearance (Biswas *et al.*, 2016). Tomato Spotted Wilt Virus (TSWV) causes distinctive yellow ringspots on mature leaves (Gleason and Edmunds, 2006).

2.3.8 Necrosis

Some viruses can cause necrotic (dead) patches on leaves and stems, and may kill growing shoots, or eventually the entire plant (Mathews, 2010). The unique necrotic pattern of symptoms is often main features of some diseases where the infection may rapidly spread throughout the plant and the entire leaf is killed (Potatovirus X and Potato virus Y) (Biswas *et al.*, 2016).

2.3.9 Tumor formation

Sometimes virus may cause a range of tumor-like growths (Green, 1991) and the best example is wound tumor virus. Occasionally, wilting of aerial parts induced by virus infections where the whole plants may go up-to death situation (Citrus tristeza virus) (Biswas *et al.*, 2016).

2.3.10 Shoe-stringing

A severe symptom is "shoe-stringing" of the leaves where the leaf blades are shrunken to less than the width of the veins. In tomato, it is the most characteristic symptom of Cucumber Mosaic Virus (CMV) characterized by filiform-like leaf blades. It can be transitory, with severe symptoms to lowest leaves or top young leaves as well as nearly normal middle leaves. High severity to tomato plants causes maturity delaying, reduction in yield and fruit size and often mottled or necrotic (Zitter and Murphy, 2009). In blueberry, it is caused by blueberry shoestring virus (BSSV)(Schilder and Miles, 2008).

2.3.11 Hypoplasia and hyperplasia

Due to viral symptoms, some histological changes are frequently occurred within the plant which are referred as hypoplasia and hyperplasia. Hypoplasia may refer to localized retarded plant growth numerously leading to thinner areas on leaves whereas leaf lamina become thicker than the dark green areas. On other hand, hyperplasia referring to swelling of leaf tissues of plant due to growth of abnormally large cell or excessive cell division (Biswas *et al.*, 2016).

2.3.12 Local lesions

Local chlorotic (yellow) lesions may develop at or near the site of infection with different diameter and size (Kumar and Waliyar, 2007). Such local lesions occurs due to a hypersensitive reaction at the zone of inoculation and may prevent spread of the virus from the site of the lesion (Randles and Ogle, 1997).

2.4 Nematods

These are microscopic but complex unsegmented roundworms that are anatomically differentiated for feeding, digestion, locomotion, and reproduction. Most of nematode species are beneficial to agriculture; they make important contributions to organic matter decomposition and are important members of the soil food chain. However, some species are parasitic to plants and may cause large destruction to crops. The following are symptoms of nematodes;

2.4.1 Lesions

Involves stunting of roots, lacking root hairs, reduced root volumes and weights, black discolored areas present on roots (lesions), (Speijer et al. 1997). They are causedby *Pratylenchusspp* (Lesion nematode) which degrade cells in the epidermis and cortex of underground plant organs. These activities reduce the amount of root branching and the ability of roots to absorb water and nutrients hence wilting, (Oregon State University et al 2010).

Foliar symptoms may include; yellowing and premature death of lower leaves, poor vigor, stunting, reduced tillering, reduced grain yield and grain quality, and an increased foliar temperature, reflecting impaired leaf cooling due to restricted water uptake (Richard 2015). Affected areas of fields appear generally unthrifty, yellow (especially lower leaves), or droughty, (Oregon State University *et al* 2010.)

2.4.2 Yellow patches

Caused by Lance Nematodes (*Hoplolaimus spp. /Tylenchorhynchus spp*.). Lance nematodes parasitize a wide variety of hosts. Many trees, crops and grasses are subject to damage, including cotton, pine, oak, wheat, corn, beans, bananas, peas, cabbage, sweet potatoes, peanuts, chrysanthemums, sycamore, apple, clover, alfalfa and lawn grasses. Symptoms include, stunted root systems with missing feeder root, but galls are not present, (Handoo, 2007). Problem areas are generally clustered in a field. Aboveground symptoms of lance nematode damage include patches of yellowing, dying and poorly rooted, (Ravichandra, 2010). It is hard to diagnose lance nematode damage just by observing symptoms, since the symptoms are similar to other stresses including insect damage, disease, drought and nutrient deficiency (Patton et al 1999.)

2.4.3 Rootstunts

It is caused by Sting Nematode (*Belonolaimus spp*.). The host plants include; Soy bean, Wheat, Sorghum, Barley, Rye, Oats, Peanuts. Possible symptoms include, stop root growth giving roots the appearance of being cut, (Douglas 1999). Seedling plants may sprout and then cease growing completely in larger populations, (Crow et al. 2005). If the root tip is destroyed, new roots may be produced above the damaged area, resulting in a highly-branched appearance, (Douglas 1999).

2.4.4 Stubby Root and corky ringspot

Caused by Stubby root nematodes:*Trichodorus spp.* Feeding causes growth and elongation of the roots to cease leading to a "stubby-root" appearance having dark, shrunken lesions, particularly at the tips, (Michelle and Fraedrich, 2004). With high population densities, complete root destruction can occur, (Decreamer W. 1991). On tuber or root crops, sting nematodes can cause direct damage by causing stunting and malformation of edible portions, and corky ringspot, (Mojtahedi et al. 1999, Westerdahl, 2014). Above ground symptoms may include; reduced vigor, slow growth, and stunting, (Hunt DJ. 1993). The foliage of affected plants may turn yellow or red due to nutrient deficiencies in the foliage resulting from an impaired root system or to physiological responses in the plant in response to nematode feeding, (Mojtahedi et al 1999).

2.4.5 Galls

Root-knot Nematode (*Meloidogyne spp.)*infection can also cause galls as previously described in bacterial and fungal infection. Infected roots swell at the point of infection and form knots or galls as a result of nematode feeding. Several infections may occur along the same area resulting in large fleshy galls, (Hussey et al, 2002). Leaves on infected plants may wilt at midday more readily than healthy plants, (Mitkowski, and Abawi, 2003). Because galled roots have only limited ability to absorb and transport water and nutrients to the rest of the plant, severely infected plants may wilt even in the presence of sufficient soil moisture, especially during the afternoon, (Department of Agriculture and Fisheries, 2015). Plants also may exhibit nutrient deficiency symptoms because of their reduced ability to absorb and transport nutrients from the soil, (Mitkowski, and Abawi, 2003).

2.4.6 Root-tip swelling.

The Needle Nematodes (*Longidorus spp.*)is the causative agent of root tip swelling. They are extremely large ecto-parasitic nematode, not found in roots, remains in soil as it feeds. They normally cause terminal swelling of the roots which may be elongated or slightly curved, necrosis and dwarfing of small feeder roots, (McGowan, 1982). Feeding by the nematode causes root growth to be thickened and stubby with short, stiff root hairs that resemble herbicide injury. (Mark Jeschke and Jeff Mathesius2016). Patches of stunted plants may be observed early in the season, (Koenning, S. R., and P. Wiatrak, 2001).

2.4.7 Yellow dwarf

"Yellow dwarf" is an appropriate description for symptoms that are commonly caused by Soybean Cyst Nematode (SCN) *Heterodera spp.,* (Jones et al. 2013). Roots infected with SCN are dwarfed or stunted, (Davis 2005). SCN can decrease the number of nitrogen-fixing nodules on the roots, (Baldwin 1991).Once nematode enters the plant roots, will remain sedentary while feeding. Dead females (cysts) can remain in the soil for 12+ years and still produce eggs when soybean plants are introduced. The obvious symptom of SCN injury to soybeans is the appearance in the field of circular- or oval-shaped areas of stunted, yellowed, less vigorous plants, (Tylka, 1994). These infested areas will vary in their size, often showing a sharp dividing line at the edges between stunted and apparently healthy plants, (University of Minesota, 2011). Rows of soybeans grown on SCN-infested land frequently are slow to close or fill in with foliage, (NgaireRoughley and Linda Smith. 2015).

2.4.8 Stem rot

Stem rot describe the SoS of stem nematodes infection (*Ditylenchus spp*.), which are migratory endo-parasite found within crowns, buds, and leaves of Garlic, Onion, and Carrots, (Brewster 1994). Characterized by patches of stunted plants and deformed leaves and stems. Crowns of infected plants may become swollen and discolored, garlic bulbs turn brown, are light weight and shriveled (Brewster 1994). Also, presence of white leaf tissue (flagging). Necrosis or rotting of stem bases, bulbs, tubers and rhizomes, (Westerdahl, 2006).

2.4.9 Flagging

Very similar to nutritional deficiencies, plant stunting and discoloration may be present in higher populations (flagging). Caused by Reniform Nematode (*Rotylenchulus spp.*) in which their feeding causes damage to the plant resulting in stunting and generally poor plant growth. The reniform nematode does not typically cause complete plant death, however they reduce the productivity of the crop. Populations can be quite uniform in their distribution across a field, making detection of early plant symptoms difficult, (NgaireRoughley and Linda Smith. 2015).

2.5 Mycoplasmas

Mycoplasma species are the smallest free-living bacterial-like organisms which lack a cell wall a structure that is important for infection (Nicolson *et al.* 2000). Due to lack of cell wall, they require an insect for its transmission unto host (Hogenhout *et al*. 2008). These organisms cause diseases in crops and produces the following characteristic symptoms:

2.5.1 Yellowing

Lethal yellowing affects Palms and has been observed in Tropics especially in Tanzania, Mozambique and Kenya with fruit drop and blackening (necrosis) of new inflorescences which followed by yellowing of oldest to youngest leaves, rotting of the stem apical tissues and death of the palm (Bila *et al*. 2015).Blackening of inflorescences is the reported obvious sign which followed by coconut die in 4 to 6 month after symptoms appear, (Eziashi & Omamor 2010).

2.5.2 Abnormal shoot branching and stunted growth.

Mycoplasmas affecting conifer species indicating the symptoms of leaf yellowing, shoot proliferation and stunting (Sliwa *et al*. 2008).In maize plant the stunting of the plant affects the plants nutrient, water and other essential elements uptake resulting in dieback*(*De Oliveira *et al*. 2005). However Phytoplasmas reported to affect elm tree where shading of premature leaves droop andyellowing were observed(Martin 2012).

2.5.3 Proliferation

This symptoms occurs in atleast all plant parts including flower, stipules, Leaves, Buds, and Shoots. *Candidatus Phytoplasmamali* has reported infecting apple in causing proliferation as diagnosing symptoms. According to(Fránová *et al*. 2013; Zimmermann et al. 2015)the disease altering the signaling components, physiology and eventually collapse of sieve elements. The disease was also reported causing abnormalities in the apple plant growth(Schmidt *et al*. 2015), stone yellow and pear decline (Mehle et al. 2013). Affected shoots and back become thin, necrotic areas appear on back and branches withers with a reddish brown color but chlorosis and reddening of leaves can be caused by other agents so diagnosis should not base on symptoms only(Xu *et al*. 2013).

2.5.4 Stunting, Yellowing and witches' broom

Symptoms reveled of tropical potatoes due to mycoplasmas infection includes development of shoots or aerial tubers in leaf axils(Nasir *et al*. 2007), plants become stunted and apical leaves may curl and turn yellowish or purplish. Plants may wilt. Tubers from infected plants do not sprout normally. They are often small, flaccid, malformed, and without sprouts or with thin "hair sprouts" (Gera et al. 2011).

2.5.5 Yellows-type disease (Potato witches' broom phytoplasma)

Witches' broom disease is caused by phytoplasmas, having several symptoms including general stunting and yellowing. Host reported are Medicago sativa(Lucerne), Potatoes (*solanum tuberosum), Nicotianatabacum (tobacco) and Trifolium species* (clover). Infected plants show signs like abnormal formation of leaves stunting or rosetting Stems and witches broom Stems (Jung *et al*. 2003).

2.6 Symptoms resulting from abiotic agents

Noninfectious diseases are those caused by nonliving agents, they are usually known as plant disorders. These type of diseases are not transmitted from one plant to another.(Agrios, 2005; Mara et al., 2012).
Symptoms incited by non-infectious agent include the following;

2.6.1 Leaf scorch and oxygen starvation

These are abiotic disorders related to moister/water. Symptoms driven by leaf scorch include necrosis (browning) of leaf edges and/or between the veins,(Agrios, 2005). For oxygen starvation, plant drop leaves from the inside of the plant out and bottom up, (Agrios, 2005, Mcmullen&Lamey, 2001). Too much water can be just as damaging as not enough water, as both kill roots (Mara et al., 2012).

2.6.2 Yellowing

Yellowing is another symptom incited by plant deficient in nitrogen, start with lower leaves and progressing upward. Also chlorosis due to iron deficiency is a symptom which can be observed on the new growing leaves. When the deficiency is severe, leaves may turn brown and brittle (McMullen &Lamey, 2001).

2.6.3 Leaf margin necrosis, leaf discoloration, and rapid vegetative growth

Symptoms of nutrients excess damage include leaf margin necrosis (similar to drought stress in appearance), leaf discoloration, soft rapid growth, and vegetative growth at the expense of flower and fruit production (Agrios, 2005, Bradley &Hoiser, 1999). Fertilizer damage can also cause the same symptoms (Bradley & Hosier, 1999).

2.6.4 Leaf burn, leaf distortion, chlorosis, flattened or enlarged stems and roots

These are symptoms incited by pesticides toxicity. They include; leaf burn, leaf distortion, chlorosis, flattened or enlarged stems and roots, and plant death (Agrios, 2005). Symptom type and severity depend on the type of pesticide and the concentration of the chemical (Agrios, 2005, Bradley & Hosier, 1999). All pesticides, if used inappropriately, can be toxic to plants. In most cases, damage results from improper application or from pesticide drift. (Agrios, 2005).

2.6.5 Water soaking, yellowing and browning along the edges of leaves caused by chilling

Chilling injury occurs commonly in tropical plants at 12-13^{o}C. Symptoms of chilling damage in plants includes; water soaking, yellowing and browning along the edges of leaves. Older leaves show symptoms first. If the damage is severe, plants wilt and often die, (Weir and Cresswell 1995).

3. Conclusion and Research Opportunities

Diseases, whether due to biotic or abiotic factors pose a great threat to food security in Africa. This document highlighted major disease symptoms and or signs resulting from disease causing agents in the region. There is no doubt that most disease symptoms are complex and portray morphological similarities among different causal agents. This document has been prepared to guide crop protection experts and other users to have a clear indication of what the causal agent might be prior to deciding detection or appropriate diagnosis and or a control method.

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