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Sources of Viruses and Fungi Disease Infection of Newly Bred Hybrid Sweetpotato Genotypes and Their Control -- A Review

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Abstract: *Fungal and Virus disease organisms affecting newly bred hybrid sweetpotato genotypes have sources of infection either from previous or nearby older crops of sweetpotato. However, other diseased sweetpotato plants are usually the main source of infection for newly planted sweetpotato crop as there is generally a large amount of inoculum on old and or previous crops and the population of disease organisms coming from other sweetpotato crops are usually better adapted to infect newly bred hybrid sweetpotato genotypes than disease organism coming from other sources. Diseased sweetpotato genotypes caused by fungi produced symptoms such as leaf spot, damping off, root rot and wilting when the soil is moist, while the viral disease cause severe stunting of the plant and small malformed leaves such as leaf curling, dwarfing, leaf mottling and yellowing of veins sometimes with either a chlorotic mottle or vein clearing. These diseases cause yield losses and difficulty in breeding due to loss of vigour and failure in flowering. Therefore, the control measures for preventing disease infection in newly bred hybrid sweetpotato genotype field include: avoiding growing sweetpotato field close to each other or around the family homestead and stop facilitating movement of diseased organism between crops. It also include preventing the cultivating of sweetpotato that are often grown at intervals to each other and new crops that overlaps old ones. Again harvesting of sweetpotato piecemeal can allow the duration of the crop to be extended, allowing more time for disease organisms to build up and for the overlap of new and old crops. Discarded sweetpotato foliage and roots can re-establish themselves and even survive weed competition and grazing, providing long term sources of inoculum. Control of fungi diseases is by effective cultural measures. The measures include using disease tolerant/resistant varieties, removal of damaged sweetpotato parts and crop rotational measures with crops not susceptible to the fungi and virus diseases.*
Word index*: fungus, virus, sources of inoculum, new hybrid sweetpotato, symptoms, control*

I. Introduction

Pathogen causing diseases do not appear spontaneously in the field, they always come from other diseased plants or their remains in the field. It may be from distance places or the organisms carrying the disease may be carried by winged insects or some other means or from a previous field or close by fields (Petrini and Ouellette,1994). According to Petrini and Ouellette (1994) most disease organisms affecting newly bred hybrid sweetpotato genotypes have sources of infection either from previous or nearby older crops of sweetpotato. However, few of the disease organisms affecting newly bred hybrid sweetpotato genotypes can survive on other crops or on wild plants especially those that are closely related to sweet potato such as Morning glory. Also, other diseased sweetpotato plants are usually the main source of infection for newly planted sweetpotato crop as there is generally a large amount of inoculum on old and or previous crops and the population of disease organisms coming from other sweetpotato crops are usually better adapted to infect newly bred hybrid sweetpotato genotypes than disease organism coming from other sources.

ICRISAT (2010) and IBPGR (1997) reported that newly bred hybrid sweetpotato genotypes of various varieties (white, cream, yellow, orange and purple fleshed) can be infected with diseases such as fungi and viruses. This means that all the sweetpotato plant parts such as the leaves, petiole, vine, flower, and roots could be damaged by fungi and viruses thereby causing stunted/dwarf growth, damaged plant parts and severe yield reduction. The two major diseases attacking newly bred hybrid sweetpotato genotypes causing considerable yield and flower reduction are fungal and viral diseases.

II. Fungus Diseases

Andrews and Harris (2000) observed that newly bred hybrid sweetpotato genotypes are affected by fungal spores that deposited on the growing plant parts such as the leaves, vines, petioles or the flowers. They germinate and penetrate the plant tissue through the wound caused by insects, wind abrasion or through natural opening on the leaves such as through the stomata. The fungal filament which developed extract nutrient from the sweetpotato plants and in return excrete toxic substances into the sweetpotato plant. This eventually led to the death of the tissue of the affected area of the newly bred hybrid sweetpotato genotype plants. The fungi that

enter the sweetpotato plant through the vascular tissue or the xylem spread through the vascular bundle killing a lot of plant tissues. This led to the considerable death of the sweetpotato plant parts thereby leading to yield reduction and starvation to the farmer, scarcity of newly bred hybrid sweetpotato genotypes roots in the market, starvation for the population and lack of development of new sweetpotato genotypes.

Fungal diseases is devastating in sweetpotato fields. It can damage all parts of the sweetpotato plant ranging from the roots to the flowers. According to Juede (2004), fungal disease infection could be of primary and secondary causes of infection. The direct infection of the disease on healthy newly bred hybrid sweetpotato genotype plant parts are regarded as primary infection while when the disease attacks an already weakened, damaged or killed plant parts through a mechanical injury or by an insect infestation, it is called a secondary infection. This distinction is very important when determining the cause of damage of the newly bred hybrid sweetpotato genotype plant. Fungal diseases cause a considerable huge losses to the plant parts of the sweetpotato through leafspot and root rot (Agrios., 2005; Bailey and Mansfield, 1982).

ORIGIN AND SPREAD OF FUNGAL DISEASES IN SWEETPOTATO FIELDS According to Stathers and his co -researchers (2005), crop diseases does not appear out of nowhere, they have lifecycles and that these may be quite varied and complex. The key factor of infection is that plant diseases are always derived from previous infections. Fungal diseases have special resting stages in which the disease organism can survive for long periods of time, it could often be in the leaf litter, and may be blown in the wind onto young previously unaffected young sweetpotato crops growing in the field. These resting stages on arrival on a new young host sweetpotato plant can germinate and penetrate into the new host. For fungal diseases, their resting period can be observed as a fine dot at the tip of a mat of fine hairs protruding from the surface of the diseased leaf, stem or tuberous roots of the newly bred hybrid sweetpotato genotypes plant. The fruiting bodies can be massive and the spore form a very fine dust. Common ways newly bred hybrid sweetpotato genotypes plants can be infected are: by Spores blown about in the wind from older diseased crops, by Spores splashed up by heavy rain from leaf litter and from diseased planting material especially since the sweetpotato crop is vegetative propagated (Stathers et al., 2005). Jeude (2004) added that fungi could be spread by irrigated water, insects, wind and animals that come in contact with infected newly bred hybrid sweetpotato genotypes newly bred hybrid sweetpotato genotype plants. The fungi disease could be spread by people when they use infected planting vine material of the newly bred hybrid sweetpotato genotypes plant to propagate a new field.

The Climate is also implicated as a factor in disease development. Excessive humidity in the soil and in the air encourages the growth and survival of fungi diseases except the powdery mildew which grew in dry season. Too much rainfall coupled with high humidity leads to fungus leafspot disease. Example is the Phytophthora. However, poor drainage favours the growth of soil fungus.
Insects that chew or pierce the body parts of sweetpotato such as the leaves, petioles and vines give extra opportunity for fungi to penetrate the plant where it could cause rot on roots or leafspots on the leaves or lesion on the vines. Also, Soil fungi can penetrate the roots through lesion caused by soil nematodes in the soil. Excrement of caterpillars such as stem borers could be a supportive substrate for the growth of fungi that destroy emerging sweetpotato inflorescence.

Soil fungi can stick to people's shoes or animal legs and spread round the newly bred hybrid sweetpotato genotypes field/farm. Root fungi can be spread gradually through dead organic matter. These types of fungi cause considerable damage to the roots of sweetpotato crop thereby leading to yield reduction and loss of produce to the farmer and reproductive traits to the breeder.

III. Diagnosis Of Fungal Diseases

For proper fungal diagnosis for the newly bred hybrid sweetpotato genotypes, the symptom must show the leaf spot with light coloured fungal hyhae close to the area both on the upper and underside of the leaf. This should also be accompanied by fruiting bodies on the surface or underside of the leaf in the form of pustules or thin rod like areas which may contain a powdery substance on the either surfaces. These represented clusters of fungal spores which may be in different colours such as white, black or yellowish-brown (Cao, 1997).

After the spots had formed, the tissue around the affected areas dies off, dried, and disintegrates leaving holes where the spots were. The sweetpotato plant may try to fight back by being hypersensitive immediately the fungus invaded the plant. The sweetpotato plant tissues tried by restricting further invasion of the diseases. In so doing the tissues die with the invading fungus and the areas turn brown, disintegrate and fall off thereby restricting the invasion. The hole so created gave the disease its name Leaf spot disease (Deverall, 1995). According to Agrios (2005), the hypersensitive response, however, is highly specific and occurs only when the

product of a pathogen avirulence gene interacts with the product of a plant resistance gene. The activation of this gene in gene-for-gene resistance in the sweetpotato plant results in a cascade of reactions within the cell. The hypersensitive response (HR), led to a rapid death of a few host cells in the sweetpotato leaves limiting the progression of the infection. This is a manifestation of recognition of the pathogen by the sweetpotato plant. Agrios (2005) reported that an hypertensive reaction includes signal transduction which programmed cell death and increased activation of defense related genes and a distant induction of general defense mechanisms that serve to protect the plant [i.e. systemic acquired resistance (SAR)]. The attacked cell and several cells around it die in response to chemical signals. The sacrifice of these cells isolates the pathogen and is a particularly good resistance mechanism for some varieties of the newly bred hybrid sweetpotato genotypes (Dixon, 2001). Marcell and Beattie (2002) reported that the leaf area where the fight took place have openings or holes where the spots were and it appears as if chewing insects made holes on the leaves or that the holes were punctured with round sharp stick.

SYMPTOMS OF FUNGAL DISEASES OF SWEETPOTATO IN THE FIELD

Symptoms of fungal diseases are not restricted to a few sweetpotato plants or a particular area within a field of sweetpotato crop (Jeude, 2004). However, the symptoms are spread over the entire sweetpotato cultivated field.. According to Hammerschmidt and Kuc, (1995), the first symptom of fungal diseases in sweetpotato is partial wilting. In sweetpotato field, the lowest leaves that touch the soil turn brown and decay while in the sweetpotato seedling nursery, the stems immediately above the ground level decay and fall over as a result of a soil fungus attack. In some sweetpotato plants especially during rainy season, part of the sweetpotato plant may wilt partially or entirely. This could be as a result of blocked xylem vessel by a soil fungus called *fusarium verticillium spp* preventing the passage of water from the root to the leaves of the sweetpotato plant even though the soil is moist (Richard, 2003). Also, partial insect damage could attract presence of fungus growing in the area which could further block or restrict water flow to the upper parts of the sweetpotato plant. This could lead to the death of the sweetpotato plant even though the soil is moist enough to sustain plant life. The disease attack every part of the sweetpotato plant.

Fungi effect on sweetpotato leaves/vines: The most visible symptom of fungal disease is Spots on the leaves hence the name leaf spot disease of sweetpotato. Fungi attack the sweetpotato leaves causing Spots on the leaves. The Spots are normally round or oval. It could also be rectangular. They are located on the leaf surface and seldom limited to the area near the leaf edges (Jeude, 2004). Agrios, (2005) observed that at the early stage of infection, moist areas may be noticed on the leaf which later die and fall off. This is caused by a kind of fungus called Phytophtora infestans. In older leaves, the infected tissues die and turn brown; the spot is surrounded by a light or dark coloured halo. Later, a layer of concentric rings of different shades of brown or grey also form around the centre. However, these types of symptoms could be caused by a fungus or bacterial infection.

In older sweetpotato plants, soil fungi could infect the vines and leaf petioles close to the soil surface when rain drops splash on the soil and covers these plant parts close to the soil surface. Sweetpotato plants above the ground far above soil splash could be affected by fungus transported by the air thereby causing vine or petiole cankers. Vine or petiole cankers could also be caused by bacteria except if well diagnosed to indicate presence of hyphae and powdery substances could fungi be implicated.

In some sweetpotato genotypes that have thick vines, the tip and top die back. The youngest part of the leaves and the tip thinner layer of epidermis are very susceptible to fungus invasion. The first sign of newly bred hybrid sweetpotato genotypes damage is the formation of sunken spots on the young shoots and tops, the young leaves defoliate and turned dried. The dying off continues downward direction until it stops on its own. This is caused by the fungus *Colletotrichum spp* and *Rhizoctonia spp*.

Fungal effect on tuberous roots: Fungi also attack the enlarged tuberous root of sweetpotato and the feeder roots. When this happens, the leaves of infected sweetpotato plant became limp, then turn brown, wilt and eventually fall off. This led to considerable yield reduction because the enlarge tuberous roots which is the economic part of the roots decay due to rot. While the feeder roots die off as a result of rot leading to the death of the entire plant. Since the fungi attack the sweetpotato roots, the plant growth is retarded, the roots dies off and the whole root is black producing watery smelly odour (Andrews and Harris. 2000). In most cases, the fungus tissue or mycellium can be seen in or between the wood and bark of the sweetpotato vine close to the soil in the form of white, red, brown or black rhizomorphs, In severe cases, sunken spots appear on the roots or on the vine base close to the soil surface. This sunken spots contains fruit bodies with spores containing burst black powder which have been released and dispersed in most of the advanced stages. In most roots of sweetpotato,

only few fungi such as *Synchytrium* and *Spongospora spp* can cause cork wart and scabs on the enlarge roots, feeder roots or on vine close to the soil level.

Fungus effect on the flowers and capsules: Fungi attack sweetpotato flowers and capsules (containing the seeds) in the field especially during wet weather. When this happens, smut and bunt fungi attack the capsules containing the seeds turning them into a mass of powdery black or green waxy spores. According to Jeude (2004). seed yield losses can be as high as 80%. This is a bad news to Sweetpotato breeders who depend solely on the seeds for new varietal development through hybridization of parents by polycross and controlled crosses. Collected seeds from the field are damaged in storage before planting by fungi as a result of too much moisture. The storage area became smelly and fungus tissues grew among the seeds. This affects the seed quality and germination thereby causing the germination capacity to decline drastically due to the presence of the fungus. The biochemical conversions that take place in the seeds as a result cause the seeds to die preventing new generation of sweetpotato plants. Immediately after sowing, the planted seeds can become infected by soil fungi. This could wipe out a whole lot of planted sweetpotaio seeds. The sweetpotato seeds could die before they become seedlings or the germinated seedlings could even die before they emerge above the soil surface. Sometimes the fungal tissues are visibly seen on the germinated seeds. If a limited parts of the cultivated sweetpotato field are sick, while the other part are healthy, the likelihood is that the infection is as a result of soil fungus or nematode infection.

Effect of fungus in Sweetpotato Seedling Nursery:Fungi attack sweetpotato seedlings in the nursery causing seedling collapse. This happens in newly bred hybrid sweetpotato nursery especially during growth or immediately after germination of sown seeds. Newly bred hybrid sweetpotato seedlings collapsed as if hot water had been poured on their stems. This is called damping off. It could also occur as a dry rot which develops on the stem immediately above soil level thereby causing collapsing of seedlings. This is caused by a soil borne fungus called *Pythium*, and *Phytophora spp* (Kimberly et al., 1995).

HOW TO DIAGNOSE FOR FUNGUS INFECTION IN NEWLY BRED HYBRID SWEETPOTATO GENOTYPES

The fungal infection is very similar to those of a bacterial infection. To be sure which pathogen has cause the damage in the newly bred hybrid sweetpotato genotypes in the field, specific pesticides are applied. First, the sweetpotato field is divided into two, one half of the sweetpotato field is treated with the fungicides Benonyl + Etridiazol (Mancozeb, Maneb or Dithane Mancozeb, Maneb or Dithane). This combination is effective for all fungi. If the newly bred hybrid sweetpotato genotypes plant health condition does not improve then, bacteria is the cause of the problem. To be effective, the fungicides should be treated a number of times in succession in the environment especially if it is a fungal prone area. In this way, there will be assurance that the newly bred hybrid sweetpotato plants will be free of fungal infection and symptom for a specified period.

If fungi tissue is not found in the fungal treated sweetpotato area, the presence of fungal can still be revealed in the laboratory by cutting a 3 - 15 cm strip from the affected plant part and placed it in a plastic bag lined with a layer of cotton wool which had to be kept damp with water. The plastic box or box top can only be slightly open so that it stays very damp inside the box or bag. If a fungus is present on the plant tissue, it will manifest itself within a week by developing a significant amount of fungal tissue. This could be identified under a microscope. The fungus could be secondary infection that develops on previously damaged or dead tissue. The fungus itself may not necessarily have been the cause of the tissue's death.

CONTROL OF FUNGAL DISEASES IN NEWLY BRED HYBRID SWEETPOTATO GENOTYPES

Control of fungi diseases is by effective cultural measures. The measures include using disease tolerant/resistant varieties, removal of damaged sweetpotato parts and crop rotational measures with crops not susceptible to the fungi diseases. National crop research Centres like National Root Crops Research Institute, Umudike, Abia State- Nigeria have developed a number of varieties resistant/tolerant to fungus diseases such as TIS87/0087, TIS8164, Shaba and2523.OP.1.13. However, the variety UMUSPO/1 is moderately susceptible to leafspot disease. Spreading the newly bred hybrid sweetpotato plants with fungicides such as Macozeb to protect the young seedlings and treating seeds with systemic fungicides will give the crop long term protection.

VIRUSES

Viruses do not have a form that by itself can penetrate the protective skin of a new host so as to infect it. They rely on other organisms such as plant sucking insects like whitefly, leafhopper or aphids that feed on sweetpotato (Tairo et al., 2005, Ahmad et al., 2006). The plant sucking insects carry the virus from infected sweetpotato plant to uninfected newly bred hybrid sweetpotato plant to infect it. So if such insects are stopped

from feeding and moving from an old diseased sweetpotato to a new health sweetpotato crop, this can prevent sweetpotato plants in the new crops field becoming diseased (Clark and Moyer, 1988). However, only one type of insect can transmit a particular virus. Therefore according to Stathers and his co-researchers (2005), only whiteflies can transmit sweetpotato chlorotic stunt virus disease in sweetpotato (and cassava mosaic disease in cassava), while only aphids can transmit sweetpotato feathery mottle virus. Virus disease can generally be spread quickly through the whole of sweetpotato plant and field. This means that vine cuttings taken from even seemly a healthy looking part of a sweetpotato plant can probably be infected (Ames, 2002 and Panta et al., 2007).

ORIGIN AND MODE OF SPREAD OF VIRUS PATHOGEN IN NEWLY BRED HYBRID SWEETPOTATO GENOTYPES

A virus infection is often spread by piercing sucking insect vectors which move from plant to plant. The viruses of many plant pathogen such as those causing leaf curl, leaf chlorosis, leaf mosaic, vein clearing, leaf deformation and stunting of plants, are responsible for the most frequent and most widespread epidemics carried in the air by insect vectors and can be dispersed by air breezes or strong winds over distances varying from a few centimeters up to several kilometers (Jeude, 2004). Viruses are the next most important group of pathogens in terms of their ability to cause sudden and widespread epidemics. These viruses include those whose inoculum is carried by airborne and soil vectors. Many of the viruses are transmitted by aphids, whiteflies, and some other insects, and in the soil by nematodes (Jeude, 2004). Viruses have caused tremendous yield reduction in many fields under cultivation with sweetpotato varieties.

Viruses are usually spread to newly bred hybrid sweetpotato crops by insects (vectors) that have sucking mouth parts, especially aphids, plant hopers and whiteflies, but other insect orders and families can also be responsible. These insects can come from the direct vicinity or from far away fields. For instance, the sweetpotato virus diseases are spread by aphids that can be carried hundreds of kilometres by air currents (Jeude, 2004). The infection can come from distant places, especially places where wind or typhoons occurs. Viruses can also be spread by human hands that have come in contact with an infected crop or crop products (Jeude, 2004). Vegetative propagated plant material can spread viruses when they are used as planting materials in the field. Soil viruses can be spread by nematodes and certain soil fungi (Jeude (2004). Sweetpotato field infested with nematodes can equally be attacked by viruses. Sweetpotato varieties can carry a virus without being significantly damaged by it. This indicated that not all sweetpotato varieties are equally susceptible. However, in course of time could breakdown to virus infection as a result of accumulation of viral load by the vines. However, the only proven vectors of sweetpotato viruses are aphids and whiteflies (Stathers et al., 2005).

The *sweetpotato mild mottle virus* (SPMMV) and *sweetpotato chlorotic stunt virus* (SPCSV) are transmitted only by whitefly predominantly *Bemisia spp*, while *sweetpotato feathering mottle virus* (SPFMV) and the related *sweetpotato virus 2* (SPV2) and *sweet potato virus* G (SPVG) are transmitted by aphids. Some weeds such as Morning Glory harbor the viruses but the only economically important source of infection is other infected sweetpotato plants.

VIRUSES' SYMPTOMS OF SWEETPOTATO VARIETIES

Vegetative propagation, which is usually the taking of vine cuttings from a previous crop, increases the risk of a buildup of viruses. Stathers et al., (2005) observed that it can cause vein clearing and purple ring spots on the leaves of susceptible varieties. SPCSV on its own cause dwarfing of sweetpotato plants and either purpling or yellowing of lower leaves. Both viruses cause yield loss when sweetpotato plants are affected. For instance, in South Africa and China yield increases of more than 30% occurred as a result of planting virus-free planting material.

When newly bred hybrid sweetpotato plant is infected with both SPCSV and SPFMV, the symptoms become very severe SPVD. Symptoms include severe stunting of the plant and small malformed leaves such as leaf curling and dwarfing, leaf mottling and yellowing of veins sometimes with either a chlorotic mottle or vein clearing. These symptoms are most apparent in young sweetpotato plants as they get established, although plants can be infected at any age.

VIRUS SYMPTOMS OF SWEET POTATO VARIETIES

The tissue of sweetpotato plant damaged by a viral disease does not die off immediately. It does not display any necrotic spots or areas. The most important symptom of viral infections is the light (white and yellow) color of the leaves or a mosaic pattern of light and darker shades of green on the leaves. Larger spots (sometimes in an oak-leaf pattern) can also appear within which a 'rain-stripe' pattern (with multiple yellow or

pale green, narrow, parallel lines and bands) is visible. The spots that form the mosaic patterns can be angular (bordered by the leaf's veins) or rounded and sometimes even ring shaped. The latter example usually involves a soil virus. The leaf veins often also become lighter in color appear waxy and have a thin, darker-colored streak on either side (i.e. vein - clearing) (Islam et al., 2002). The symptom of viral infection on sweetpotato genotypes are often not found on all the cultivated sweetpotato plants in the field as is usually the case in fungal while in some cultivated areas of sweetpotato genotypes, a whole field can show the symptom of viral infection. It is almost always possible to find a number of sweetpotato plants that show no signs of the disease at all.

Nevertheless, Sweetpotato field with a large number of plants affected by viruses or by sweet potato virus disease complex show the following general visible symptoms on the plant: stunting, mosaic, and leaf deformation. Sometimes the vein clearing is surrounded by purple pigmentation (Tairo, et al., 2005). Abnormal (lighter) leaf color, abnormal leaf and stem shape, dwarfed growth and mosaic patterns on leaves can, however, be signs of a nutrient deficiency as well as a viral infection or nematode infestation (Ames, 2002). A viral disease cannot be diagnosed with any certainty at first glance or without laboratory tests. This is due to the fact that virus infected sweetpotato plant may look healthy and vigorous.

TESTS FOR THE DETECTION OF VIRAL INFECTION IN NEWLY BRED HYBRID SWEETPOTATO GENOTYPES

Due to absence of symptoms from single infections in sweetpotato by most viruses, simple tests are sometimes carried out. The best approach in this case is probably to conduct a few simple tests to determine whether the anomaly could be caused by a deficiency or nematode infestation (Jeude, 2004). This can be done by spraying a nutrient solution of micro- and macro-elements on the affected sweetpotato plants and applying a nematicide to see if this brings about any improvement in the sweetpotato plant's condition. If not, then it is indeed likely that the damage is caused by a viral infection.

Another test is Sweetpotato virus indexing: This is accomplished by grafting sweetpotato cuttings onto indicator plants and symptoms are evaluated after four weeks (Panta et al., 2007). Grafting and in some cases sap transmission onto indicator plants is often required to increase virus concentration and detect viruses reliably (Nakasawa and Ishiguro, 2000). Commonly used indicator plants are: *Ipomoea setosa, Ipomoea nil, I. purpurea, I. aquatica, and in some cases Nicotiana benthamiana* and *N. clevelandii.*

PREVENTION AND CONTROL MEASURES OF VIRUSES IN NEWLY BRED HYBRID SWEETPOTATO GENOTYPE FIELD

Newly bred hybrid sweetpotato genotypes break down to virus infection after every 5 to 7 years of release depending on the genotype and viral load in the environment. As such Swweetpotato breeders are constantly at work looking for resistant/tolerant varieties. Large screen houses covered with netting materials are used to protect disease-free planting materials that are imported or from tissue culture laboratories from insect vectors attack. Vine multipliers at community level use small net tunnel as screen house to increase farmers' access to quality disease-free sweetpotato planting material. These lower the cost of maintaining virus planting material on the farm. Farmers need to use net tunnels to continually renew high quality foundation planting material in their newly bred hybrid sweetpotato field. According to Miyakonojo (2007) and Bashaasha et al (1995), effective vector control remains the only approach available to suppress virus amplification and prevent sweetpotato plants infection. This can be achieved using an integrated management approach that focuses on insects' vector population suppression through habitat inspection and larviciding (Islam et al., 2002). Gibson et al (1997) and Wolfgang (2012) observed that viruses spread very fast through the vascular system of a plant to entire plant and then spread to all plant population in the cultivated field. Newly bred hybrid sweetpotato plants that show symptoms of a viral disease have to be removed from the rest of the sweetpotato crops in the field and destroyed as soon as possible especially if the aim is for tuberous root production. However, if the objective is for breeding for viral resistance, it is preferable to allow the diseased plants to grow alongside the healthy plant to know the healthy plants' response to viral infection. If it is susceptible, it indicates that the sweetpotato plant is susceptible to viral infection.

If a virus spread through seeds especially during seedlings evaluation in breeding programmes, the seeds can sometimes be neutralized by soaking the seeds in warm water before planting. Viruses cannot be treated with chemical agents. The most important way to prevent a viral infection is to use virus-free seeds and vine planting material (Loebenstein et al., 2009). It is possible, however, to control the vectors (insects, nematodes) by applying chemicals, or often by adhering to strict sanitary measures during periods when a susceptible crop, or another botanically related crop, is not allowed to be cultivated on a particular field or during a particular period (Wambugu, 1991). Burning infected plants, isolation and planting of new fields far away (more than 100m)

from old sweetpotato production field are additional ways in the control of viral diseases to maintain or increase sweetpotato production (Panta et al., 2007).

Jeude (2004) observed that it is very difficult to disinfect soil that has been infected by a virus. Carey et al (1998) suggested that the best approach is to cultivate sweetpotato genotypes that are not susceptible to that particular virus or to initiate a fallow period during which the soil can receive a great deal of sun exposure. Improved, virus resistant sweetpotatoes are available at the National breeding programmes such as National Root Crops Research Institute, Umudike, Nigeria. Using resistant sweetpotato varieties such as UMUSPO/1 and UMUSPW/2 are the easiest way to prevent viral infection.

The production of virus free sweetpotato variety is achieved almost exclusively by meristem culture in vitro. In meristem culture, the essence is to take as large a meristem as possible, while excluding virus infected tissue. Therefore, smaller apical (meristematic) ex-plant might be clean from virus but not a longer apex subtending some leaf primordia (Henderson et al., 1984). Virus cleaning of sweetpotato by meristem culture is considered much more effective than by thermotherapy as Kuo (1991) noted and that with an 80% rate of virus clean shoots.

SASHA (2012) maintained that to establish sweetpotato field, cuttings for cultivating new crops should be collected from healthy sweetpotato plants. Avoid collecting cuttings for new plantings from very old crops because SPVD may have built up in these crops and SPVD is less easy to see in old plants than in vigorous-growing crops. The following are a summary of control measures in newly bred hybrid sweetpotato field as mentioned by (Stathers et al., 2005): Avoid planting new crops where sweetpotato was grown in the last season. Karyeija et al (1998) suggested removing any diseased plants or plant parts as soon as they appeared and that roots and cuttings from old surviving diseased plants in the soil will produce disease plants which act as source of inoculums to the new crop. Karyeija and his fellow workers (1998) and Gibson (2000) agreed that planting newly bred hybrid sweetpotato crops far away from old crops to make it difficult for whiteflies and aphids to reach the new crop.

Sanitary procedures to follow include crop hygiene such as ensuring that newly cut crop debris, leaves and roots are completely destroyed by fire or fed to livestock. Viruses attacking plants do not infect animals. Plant resistant varieties, is the most convenient means of controlling SPVD (Clark et al., 1998).

BIOLOGICAL CONTROL BY THE USE OF NATURAL ENEMIES OF VIRUS VECTORS IN NEWLY BRED HYBRID SWEETPOTATO GENOTYPES

The lady bird beetle is an important predator of aphids. The wings of the adult beetle are red, but some species have yellow wings. Black markings are usually present on the wings. The eggs are easily distinguished by their upright oblong grouped arrangement. They are usually yellow or orange. Other important predators of aphids are the lacewing and flower- fly (*Syrphid*). The adult lacewings are light green. The flower-fly hovers around flowers. Both the larvae and the adults are predacious. A single larva can consume a few hundred aphids.

Viruses require living organisms to survive. Almost all viruses are destroyed when an infected plant dies. However, many fungal and bacterial diseases can survive on plant debris and decaying organic matter in the soil for long periods of time until new host plant become available. Disease pathogens can also survive between cropping seasons or in the soil especially in crop debris and spread by water particularly in water droplets (aerosols) generated from rain splashes and wind. Animals particularly flying insects, infected planting materials, and contaminated farm equipment, such as plough, disc etc could easily transfer viruses to healthy sweetpotato crops growing in the field.

Although sweetpotato viruses cannot survive in dead plant debris, sweetpotato is propagated by vine cuttings and cuttings taken from virus diseased plants are generally infected (Kreuze, 2002). These can then act as important sources of inoculum for a newly planted crop. Also, unharvested roots example, roots left in the field because they were badly infested by weevil and so on, can carry viruses if they were produced from a virus infected plant and any new foliage sprouting from such roots will also be virus infected. These left over/ratooned sweetpotato plants should not be collected for planting.

Gasura and his co-workers (2008) observed that the development of a virus infected sweetpotaton crop depends on: the amount of incoming disease organisms (inoculum), the Level of resistant of the sweetpotato varieties, the general health of the sweetpotato crop particularly in relation to nutrition, the high level of Nirogen which leads to more intense fungal infections, the soil type and composition, the temperature and humidity of the

environment, the general warm humid weather and soil that favour the growth of fungi, Several of these factors are beyond the farmers' control.

IV. Conclusion

The factors associated with newly bred hybrid sweetpotato cultivation that may favour disease organisms are: sweetpotato field that are often grown close to each other, around the family homestead that facilitate movement of diseased organism between crops. It also include Crop of sweetpotato that are often grown at intervals to each other and new crops that overlaps old ones. Again, harvesting sweetpotato piecemeal can allow the duration of the crop to be extended allowing more time for disease organisms to build up and for the overlap of new and old crops. Discarded sweetpotato foliage and roots can re-establish themselves and even survive weed competition and grazing by animals, providing long term sources of inoculum. Some plants such as Morning glory often grow wild as weed or may be cultivated for their flowers as ornamental around homesteads and may act as host to viruses. Any action taken, to reduce the above factors may help reduce the amount of disease inoculum in the sweetpotato field and so help achieve control. Pest vectors are major source of infection for newly bred hybrid sweetpotato varieties.

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