http://dx.doi.org/10.22161/ijeab/3.5.4 *ISSN: 2456-1878*

Status and Management of Cashew Disease in Tanzania

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Abstract**—** *Cashew (Anacardium occidentale L.) is one of the most important export crops and the main source of cash income in the southern part of Tanzania. However it is challenged by a number of factors such as drought, declining soil fertility, un-improved low yielding cashew genotypes, insect pests and diseases. Of these factors, diseases have been cited to result in high production costs, poor nut quality and low market price. The most devastating diseases that attack cashew are powdery mildew, cashew leaf and nut blight, dieback and fusarium wilt. Other minor diseases include anthracnose, damping off and leaf spots. Despite the negative role that these diseases possess to cashew growers, there is limited or no critical updated information on their current infection status and management in Tanzania. Thus, this review article discusses the status of the most important cashew diseases and their management options in the country. Such information will be vital to cashew farmers and other stakeholders in making appropriate improvements in cashew production in Tanzania.*

Keywords**— Cashew, dieback, fusarium wilt, cashew Leaf and nut blight, powdery mildew.**

I. INTRODUCTION

Cashew *(Anacardium occidentale* L.) is a perennial nut crop, native to Brazil that belongs to the Anacardiaceae family (Ohler, 1979; Masawe, 2006; Zhongrun and Masawe, 2014). It was introduced to East Africa by the Portuguese in the 16th century and it is now widely cultivated, especially in Tanzania. (Masawe, 1994; Topper and Boma, 1997). The most important product derived from the plant is cashew nuts that are processed into kernels. The crop also produces other products such as juices, jam, alcohol and non-alcoholic beverages; all of which are produced from the cashew apples (Sobhana *et al*., 2010). In Tanzania cashew is the main cash crop and the leading source of income for over 300,000 households in South-Eastern Tanzania (Kasuga, 2013). It is estimated that more than 80% of the national cashew production comes from Mtwara, Lindi and Ruvuma (Tunduru District) regions (CBT, 2015). The area under cashew is estimated to be more than 400,000hectares in mono or mixed crop production systems. An average cashew farmer owns 1-2 hectares of cashew trees (Topper *et al.*, 1997). The average yield in farmers' fields ranges from 500kg/ha to 800kg/ha (Masawe, 2006).

Cashew has been one of the most important export crops since independence in Tanzania. The cashew production increased rapidly in 1960s towards mid-1970s, recording as high as 145,000 MT (metric ton). Thereafter there was drastic decline in production up to 16,400 MT in 1973/74. The reasons for the decline in cashew nut production were drought, declining soil fertility, unimproved low yielding genotypes, insect pests and diseases (Ellias, 1980; Brown *et al*., 1984). Of the factors, diseases (Table 1) have been a major challenge in cashew since the 1970s. Of the diseases cashew powdery mildew disease (PMD) has been cited to be among important constraints to cashew production causing crop losses if not controlled ranging from 70 to 100% (Castellani and Casulli, 1981; Sijaona, 1984; Sijaona and Shomari, 1987; Intini, 1987; Shomari, 1988). The historical timeline for cashew diseases in Tanzania is shown in Table 1. In 2003, a second deadly disease known as 'cashew leaf and nut blight' caused by *Cryptosporiopsis* spp was reported for the first time, attacking cashew at all growth stages (Sijaona *et al.*, 2005; Sijaona *et al*., 2006). The disease causes crop losses of up to 48.4% annually if not controlled (ACRR, 2006). The third major disease was reported in 2012 by Tibuhwa and Shomari (2012), as cashew fusarium wilt caused by *Fusarium oxysporum*. This disease affects cashew trees leading to yield losses of up to 100% if not controlled (Tibuhwa and Shomari, 2016).

The current status of these major and minor diseases such as dieback, anthracnose, pestalotia leaf spot and damping off is discussed in this article. Such disease status information and how they are managed is vital for different cashew stakeholders in Tanzania. It can alert policy makers on how to collectively address cashew disease problems and plant breeders and or pathologists on how to develop resistant crop varieties and or integrated pest management options, respectively, against

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the diseases. A chronological history of occurrence of major cashew diseases in Tanzania is as shown in Table 1.

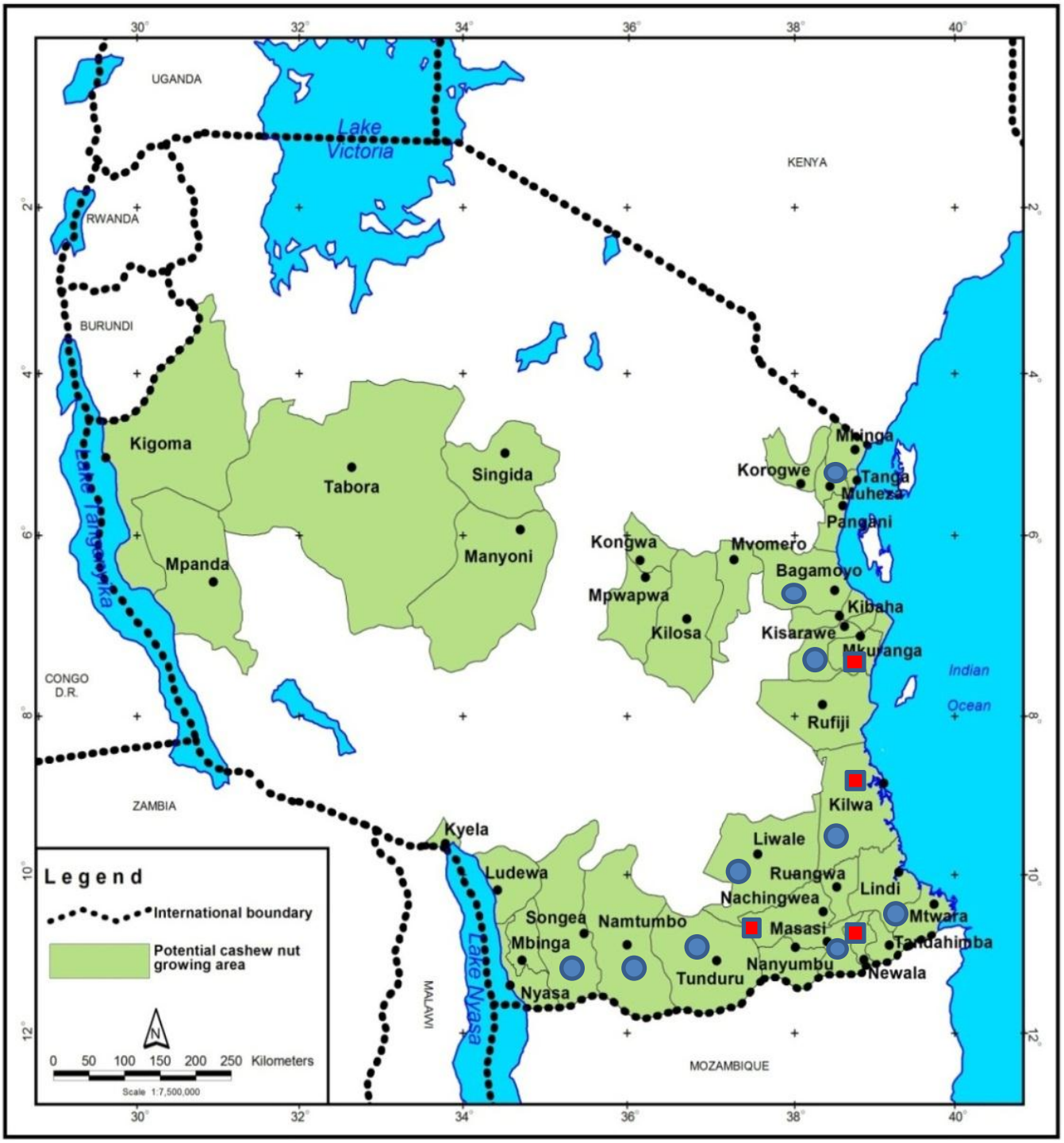

Fig.1: Distribution of cashew growing areas and major diseases affecting the crop in Tanzania (Source: ARI-Naliendele).Green coloured regions represents all cashew growing areas in Tanzania but affected by powdery mildew, dieback, and anthracnose; deep blue coloured circles represent cashew producing areas affected by cashew leaf and nut blight disease and the red coloured blocks represent locations affected by cashew fusarium wilt disease.

http://dx.doi.org/10.22161/ijeab/3.5.4 *ISSN: 2456-1878*

Table.1: Historical time line of cashew diseases occurrence in Tanzania.

S/n	Disease	Causal agent	Year reported	References
1	Cashew powdery mildew disease	*Oidium anacardii* Noack	1970	Casulli, (1979) Sijaona, (1984) Shomari, (1988)
2	Anthracnose disease	*Colletotrichum gloeosporoides* Penz	1978	Casulli, (1981)
3	Dieback disease	*Phomopsis anacardii*	1980	Intini and Sijaona (1983)
4	Pestalotia Leaf Spot disease	*Pestalotia* spp.	1980	Intini and Sijaona (1983)
5	Damping off disease	*Fusarium* spp., *Pythium* spp., *Phytophthora palmivora* Butler,	1980	Intini and Sijaona (1983)
6	Cashew leaf and nut blight disease	*Cryptosporiopsis* spp	2003	Sijaona *et al*, (2005) Sijaona *et al*, (2006)
7	Cashew fusarium wilt disease	*Fusarium oxysporum*	2012	Tibuhwa and Shomari, (2016)

II. CASHEW PRODUCTION TREND AND DISTRIBUTION OF MAJOR DISEASES IN TANZANIA

Tanzania is the world's eighth and Africa's third largest cashew nut producer after Mozambique and Ivory Coast (CBT, 2011). The main producing areas and distribution of major cashew diseases in Tanzania is as shown in Figure 1 and the production trend from 1945s shows a zigzag production style in Figure 2, nevertheless the production is currently increasing possible due to increased acreage of production.

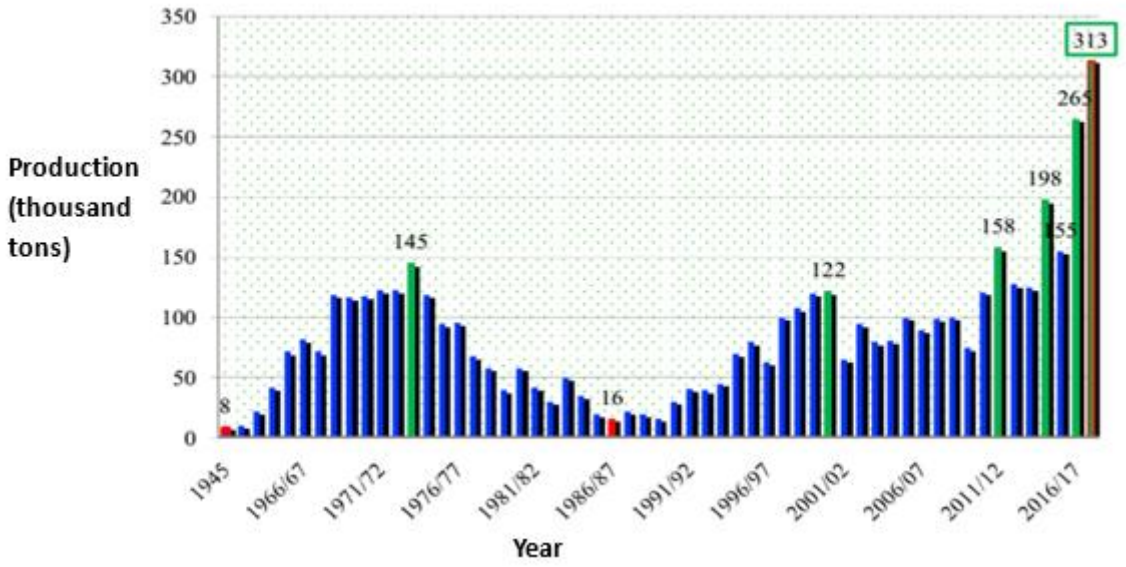

Fig.2: Raw cashew nut production trend in Tanzania since year 1945 to year 2017(Source: Cashewnut Board of Tanzania).

III. HISTORY, EFFECT, CONDITIONS FAVOURING CASHEW DISEASE AND THEIR MANAGEMENT IN TANZANIA

Cashew Powdery mildew disease

The history of powdery mildew goes back to the 1950s; however it was not economically important in Tanzania until mid-1970s (Casulli, 1979; Castellani and Casulli, 1981; Sijaona, 1984; Sijaona and Shomari, 1987; Shomari, 1988). In 1975 the rate of powdery mildew disease infection on cashew started to increase (Sijaona and Shomari, 1987) which resulted into decline in cashew production from 145,000 MT in 1973/74 to 16,4000 MT in 1986/87 (CRP Report, 2006). The decline in cashew production was consistent in all cashew-growing areas in the country, which resulted into huge losses of revenue for both growers and the government (Topper *et al.*, 1997). The increased outbreak of the powdery mildew disease was then associated with change of environmental conditions and poor cashew management resulting from villagilization program which took place in 1974/1975

(Ellias, 1980; Brown *et al*., 1984). To date, powdery mildew disease is the main constraint of cashew in Tanzania. The disease is caused by *Oidium anacardii* Noack, a fungus of genus Odium of the Deuteromycotina (Fungi Imperfecti) (Shomari, 1996; Sijaona, 1997). Powdery mildew disease infests all tender tissues of the cashew trees, mainly the tender leaf and inflorescence including the part not well unfolded. The disease seldom attacks old and mature leaves (Sijaona *et al.,* 2006). A white powdery growth is formed on the infested fruit bearing branches and inflorescence. The lesions of the infected parts turns to brown and after 2-3 weeks they shrink gradually and become dry and shed, leading to drying out and drop of numerous flowers and tender fruits (Sijaona and Shomari, 1987). Infected apples turn dull and their skin becomes much coarser. The apples when heavily infected show deep cracks on the surface and gradually shrivel and dry up (Sijaona *et al*., 2005). The tender nuts when infected are deformed on the shell. The lesions turn grey on infected tender apples and nuts. Infected nuts deteriorate in quality during storage, decays easily and produce poor quality kernels when processed (Shomari 1996; Waller *et al.,* 1997; Sijaona, 1997).

All cashew varieties are susceptible to the powdery mildew disease but at different levels. Most unimproved cashew varieties succumb more to the disease compared to improved varieties, which have a certain level of resistance or tolerance (Masawe 2006; Sijaona, 2013). The conducive environment for PMD are cold nights which are followed by warm daytimes leading to mist and fog conditions in the early mornings. An optimum temperature ranges between 25-28^{o}C with optimum at 26^{o}C. Relative humidity that is conducive to the environment ranges between 80-100% with optimum at 95% (Noak 1898; Ohler 1979; Casulli, 1979; Chacko et al. 1990; Sijaona, 2013). The PMD spores are mainly dispersed by wind as rainfall inhibits its development. However, perennation and survival of the pathogen from one season to another takes place in fallen infested leaves, water shoots and off season flowers (Sijaona *et al.,* 2006). Powdery mildew disease is not dormant and can occur on the tree canopy all the year around by wind dispersal (Shomari, 1996; Sijaona, 1997). Undertaking sanitation, which is basically the removal of water shoots underneath tree canopies, pruning branches to allow aeration, clearing of dropped branches and leaves to remove the source of the inoculum can reduce and delay occurrence of this disease for weeks (Casulli, 1979). Overlapping branches and twigs under the crown without penetration of sunlight and lack of rains are optimum condition for the powdery mildew fungus to survive (Shomari, 1996; Zhongrun and Masawe, 2014). Powdery mildew is currently controlled mainly using fungicides (chemical control). Several fungicides including sulphur dusts, wettable powders (Cassulli, 1981; Intini and Sijaona, 1984) and water based organic fungicides (Topper *et al.,* 1997; Sijaona *et al*., 2001) have been recommended for control of the PMD in Tanzania but more efforts are still going on to have more fungicides. Cashew varieties partially resistant to PMD have been developed in Tanzania (Masawe, 2006). These varieties have been commercialized and made available to farmers as grafted seedlings through Cashew Development Centres (CDCs) located in the main cashew growing areas in Tanzania. Polyclonal Seed Orchards (PSG) was established using these varieties for production of planting materials in form of seeds. Still there is a need of developing other new resistant materials for controlling powdery mildew disease to increase cashew production.

Cashew Anthracnose disease

The history of Anthracnose in Tanzania goes back to 1978 (Casulli, 1981). This fungal disease caused by *Colletotrichum gloeosporoides* Penzis not only a problem in cashew but also infects other tropical fruits trees including mango, citrus, avocado and papaya (Sijaona, 2013). The disease attacks all young and tender vegetative organs together with nuts and pseudo fruits/apples. The disease is favoured by relative humidity of 95% - 100% and temperature ranging between 22^{o}C - 28^{o}C during flowering and fruiting period (Sijaona, 2013; Zhongrun and Masawe, 2014). Early symptoms are reddish brown shinny water-soaked lesions and resin exudation on the affected parts. Infected shoots appear as “hanging nuts” Hanging nuts may act as a source of disease infection during the next season (Zhongrun and Masawe, 2014). Cashew varieties resistant or partially resistant to anthracnose were developed in Tanzania (Masawe, 2006). These varieties have been commercialized and made available to farmers as grafted seedlings. Other approaches of controlling anthracnose disease have been discussed in table 2.

Cashew Dieback disease

Cashew Dieback disease was reported in Tanzania in 1980 according to Intini and Sijaona (1983). This fungal disease caused by *phomopsis anacardii* Early and Punithalingam is believed to be facilitated by damage caused by mirid (*Helopeltis* spp) or coconut bug (*Pseudotheraptus wayii*) on cashew plant (Zhongrun and Masawe, 2014). The symptoms of the disease include withering of the panicles, followed by a progressive dieback of small flower stalks. This starts from the tips then advances downward to the main floral shoots (Intini and Sijaona, 1983). The normal greenish colour of the health shoots progressively turns brown resulting in loss

http://dx.doi.org/10.22161/ijeab/3.5.4 *ISSN: 2456-1878*

of flowers. Infected young nuts and apples become black and fluffy and remains attached to the floral stalks. Heavy infection appears similar to fire damage (Sijaona, 2013). Damage caused by insect attack (*Helopeltis* spp *or Pseudotheraptus wayii*) are considered as predisposing factors to dieback infection. The fungus attack young and tender shoots and flowers followed by dieback infection starting at tips and spreading downwards. The dieback disease of cashew is found in every cashew growing areas. The different methods used to control the infections are well explained in Table 2.

Cashew Pestalotia leaf spot disease

Pestalotia leaf spot is a disease caused by a fungus known as *Pestalotia heterocornis* Gubaand it was reported in 1980 (Intini and Sijaona, 1983). The fungus attacks mature leaves, forming angular to irregular leaf lesions, reddish brown on upper surface and pale gray to whitish on underside of leaves. Later on lesions become thinner, papery and necrotic. Severe infection may cause defoliation (Intini and Sijaona, 1983).The infected leaves show regular or irregular polyclonal lesions or round lesions. These lesions mostly appear on the leaf tip and they enlarge gradually and coalesce, expanding from the leaf tip downwards to more than half of the leaf within masses of conidia appearing on both lower and upper sides of the leaves (Zhongrun and Masawe, 2014). The pathogen develops at an optimum temperature and relative humidity range between 26^{o}C-28^{o}C and 80-100% respectively (Sijaona, 2013). The dispersal mechanism of the pathogen is mainly wind and free running water. The disease can best controlled by application of copper based fungicides (Zhongrun and Masawe, 2014), such as Kocide at the rate of 3-5 gm per litre of water at two week intervals. Other management methods are described in Table 2.

Cashew Damping off disease

Damping off cashew disease is caused by number of fungal organisms including Fusarium spp, Pythium spp, Phytophthora palmivora Butler, Cylindrocladium scoparium Morgan, Selerotium rolfsii Sacc and Pythium ultimum Trow; most of which occurs mainly at nursery (Intini and Sijaona, 1983). It was reported in Tanzania in 1980's and mainly infects young cashew seedlings in the nursery with poor drainage or container-raised young plants (Zhongrum and Masawe, 2014). The infected plantlets cease to grow and wither gradually and show circular water soaked stripes on the root collar (Sijaona, 2013). The roots may rot, leading to lodging of the plants (Zhongrum and Masawe, 2014). The nursery or the land for container raised young plants should be well drained to stop waterlogging. Seed beds can be leached by spraying with carbendazim 50% WP, Chlorothalonil 75% WP, carbendazim thiram zineb 80% WP, or cymoxanil manacozeb 72% WP. Further details on disease management are as described in Table 2.

Cashew Leaf and nut blight disease

The cashew leaf and nut blight disease was reported for the first in Tanzania in August 2002, (Sijaona *et al.*, 2005). The disease was reported in Nanyanga, Mtopwa sub-station and Chiwindi in Newala District. It was also observed in a neighbouring country at Itoculo farm in Monopo District, Nampula Province, Mozambique in 2005 (Sijaona, 2005 and Sijaona *et al.*, 2006). The disease has been reported to be more active during wet weather especially during off-season rains, where severe infections affect the young flushing material (Sijaona *et al.*, 2006). Infected cashew leaves develop silver/grey lesions with a dark reddish brown margin that enlarge and coalesce causing defoliation (Sijaona *et al.*, 2006). Infected young nuts blacken while older nuts results in characteristic dark lesions that under favourable conditions form white spore masses of the fungus within the nut lesions (Menge, 2013 and Menge, 2014). Cultural methods are done by removing, gathering, burning and burying all diseased fruits and branches and twigs left in the cashew plantation to reduce pathogen source in the field (Zhang and Masawe, 2014). Chemical methods are done by spraying fungicides such as Trifloxystrobin 10% SC, Difenaconazole WG, Picoxystrobin and Trifloxistrobin + tebuconazole (Table 2). Disease control commences when first symptoms occurs particularly during fruiting season. Two varieties which are tolerant or resistant to cashew leaf and nut blight disease have been developed and these are AZA 2 and AZA 17 (Masawe, 2006). Farmers are advised to use resistant varieties to control this disease. These varieties have been commercialized and made available to farmers as grafted seedlings (Masawe, 2006; Zhang and Masawe, 2014).

Cashew Fusarium wilt disease

The cashew fusarium wilt disease caused by *Fusarium oxysporum* was first reported in Tanzania in 2012 at Magawa village in Mkuranga Districtin the Coast region (Tibuhwa and Shomari, 2012). There after it was reported in Masasi District (Nanganga), Tandahimba District (Lindumbe) and Mtwara District (Mnongodi). The cashew fusarium wilt can cause the entire cashew plant to wilt within three to four weeks after first symptoms. The disease can attack the next nearby cashew trees until trees in the entire field are all wilted (Tibuhwa and Shomari, 2016). Infected cashew plant is characterised by gradual loss of natural green colour of leaves of some branches and then turns yellow (chlorosis) (Tibuhwa and Shomari,

2016). Looking from a distance, affected trees appear yellow and green and later within three to four weeks the entire tree(s) wilt (Tibuhwa and Shomari, 2016). Different methods including field sanitation and destruction of infected plant parts have been proposed controlling fusarium wilt disease. No other fusarium wilt managerial option has been proposed to the moment. Some fungicides have shown positive response in controlling the disease at laboratory level and field trials are in progress (Tibuhwa and Shomari, 2016). The room is open for scientists to work on in order to have positive control for this new devastating cashew disease.

Table.2: Current management options for cashew diseases in Tanzania

Disease	Causal agent	Management and description option
Cashew powdery mildew	*Oidium anacardii* Noack	**Cultural methods**:- Include sanitation by removing suckers, clearing of dropped branches and leaves also thinning and pruning unwanted branches (Casulli, 1981; Shomari, 1996) **Chemical methods**: - Sulphur dusts and Wettable powder at 250gm per tree at 14 days interval. Water based organic fungicides e.g Triadimenol, Hexaconazole and Penconazole at the rate of 10-15ml per litre per tree at an interval of 21 days (Intini and Sijaona, 1983; Sijaona, 1884 Topper *et al*., 1997; Sijaona *et al*., 2001)
Cashew anthracnose	*Colletotrichum gloeosporoides* Penz	**Cultural methods**:- Clearing off and burning of diseased and dead shoots, leaves, fruits on trees and fallen dry twigs, fruits and leaves after harvest (Sijaona, 2006). **Chemical methods**:- Chlorothalonil 75% WP 1ml per 0.6-0.8 litre, Prochloraz 25% EC 1ml per 0.8-1.5 litres, copper oxychloride, copper hydroxide, captafol, benomyl, Anilazine, Triadimenol and Dithianon (Sijaona, 2013; Zhongrun and Masawe, 2014)
Cashew dieback	*Phomopsis anacardii*	**Cultural methods**:- Remove all infected leaves on the entire trees (Intini and Sijaona, 1983). **Biological methods**:- Use weaver ants to control sucking pests (Sijaona *et al*., 2001) **Chemical method**: - use Lambda cyhaothrin EC 5 mls per litre, Beta-cypermethrin 4.5% EC 1ml per 2.5-3 litres, Dimethoate 40% EC 1ml per 1-1.5 litre and Trichlorfos 90% crystal 1g per 1 litre Zhongrun and Masawe, 2014).
Cashew pestalotia leaf Spot	*Pestalotia sp*.	**Chemical methods**: - Metalaxl Mancozeb 58% WP (1g per 0.8-1litre), Chlorothalonil 75% WP (1g per 0.8-1litre) and propamocarb 72.29% (1g per 0.8-1 litre) (Zhongrun and Massawe, 2014).
Damping off disease	*Fusarium* spp., *Pythium* spp., *Phytophthora palmivora* Butler,	**Cultural methods:-**The nursery and the land container raised young plants should be well drained to stop waterlogging (Sijaona, 2013; Zhongrun and Massawe, 2014). **Chemical methods**: - Carbendazin 50% WP (1g/0.5-1 litre), chlorothalonil 75% WP (1g/0.8/1 litre) and cymoxanil manacozeb 72% WP (1g/0.5/1 litre) (Zhongrun and Massawe, 2014).
Cashew leaf and nut blight	*Cryptosporiopsis* spp	**-Cultural methods: -**Clear off, gather, burn and bury all the diseased fruits and leaves infected in the field (Sijaona, 2006). **-Chemical method:-** Fungicides are used such as difenaconizole 14g/litre, Pecoxystrobin 10 mls per litre, Chlorothalonil 14 g/l Trifloxistrobin+Tebuconazole 14mls per litre (Sijaona, 2006) **-Resistant varieties:-** Such as AZA2 and AZA 17 (Masawe, 2006)
Cashew fusarium wilt	*Fusarium oxysporum*	**-Cultural methods:-** Clean the equipment after use and plant satisfied materials from authorised institutes (Tibuhwa and Shomari, 2016)

IV. CONCLUSION

This document highlights the status of the most important cashew diseases and their management options in the country. The information provided here is vital to cashew farmers and other stakeholders in making appropriate improvements in cashew production in Tanzania. However, there is need to conduct in-depth research especially on characterizing pathogen strains and

developing appropriate management options that will discourage use of chemical pesticides for environmental safety and improved cashew production in Tanzania.

ACKNOWLEDGEMENTS

Authors acknowledge the Nelson Mandela African Institution of Science and Technology for providing an opportunity to undertake a course in Applied Plant Pathology which created grounds which resulted in the development of this document. The Naliendele Agricultural Research Institute is acknowledged for sponsorship of my post graduate studies and also financial support in field practical.

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