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Occurrence and Severity of Physiological Disorders of Oil Palm (*Elaeis guineensis* Jacq. L.) in Uganda

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Abstract

In Africa, oil palm is grown in 25 countries supported by corporate investors. In Uganda, commercial oil palm cultivation began in 2005 in Bugala Islands. Seedlings were imported from countries with established breeding programs. These seedlings were grown in areas with different environmental conditions which have resulted in a number of physiological disorders. The aim of this research was to determine the major physiological disorders in oil palm fruit bunches in Uganda. The study was carried out in the adaptive trials in Kagadi, Bugiri, Buvuma and Masaka Districts and in the different smallholder farmer blocks in Kalangala District. Data was collected on bunch rot, bunch failure and uneven ripening. Sampling was carried out in oil palm plantations above five years of age. Three fields were selected from each unit and three units from each block by the help of the Agricultural Extension Officers (AEOs). Palms were randomly sampled and assessed for presence of bunch rot, bunch failure and uneven ripening symptoms. The incidence was expressed as a percentage of the total number of palms sampled while the severity of bunch rot disease was scored on a scale of 0-4. From the results, the differences in bunch rot and bunch failure in adaptive trials were statistically significant as well as across seasons ($P < 0.05$). Uneven ripening was not statistically significant and severity of bunch rot in the different farmer blocks in Kalangala was statistically significant ($P = 0.03$). Uneven ripening was high across smallholder farmer blocks in Kalangala and was statistically significant ($P = 0.05$) even across seasons ($P < 0.05$). These results are important for sensitization of farmers on management of oil palm disorders and essential for guiding policy makers and investors as the oil palm industrial sector is being developed in Uganda. This study calls for determination of water deficit at the various ecological zones and its relationship to physiological disorders as a guide for further oil palm estate development.

Keywords: oil palm, bunch rot, bunch failure, uneven ripening, yield loss

1. Introduction

The Oil palm (*Elaeis guineensis* Jacq. L.) belongs to family Aracaceae, subfamily Cocoideae and genus *Elaeis*. The genus has two main species *E. guineensis*, the African oil palm which is the commercial type and *E. oleifera*, the American oil palm which is mainly for breeding purposes (Nambiappan et al., 2018; Verheye, 2002). Oil palm is believed to have its origin in the Niger delta, particularly in the belt between Guinea and North Angola in West and Central Africa (Denis, 2014). It is a perennial tree cultivated in high rainfall areas close to the equator (Barcelos et al., 2015).

Globally, Palm oil production volume is anticipated to attain an annual growth rate of 5.9% from 2019 to 2024 reaching 98.82 Million metric tons in 2024. (https://www.businesswire.com/news/home/20200407005615/en/Global-Palm-Oil-Market-Insights-Trends-Forecast). Asia (Indonesia, Malaysia and Thailand) is the largest producer, followed by Africa, Americas and Oceania. In Africa, oil palm is grown in 25 countries and is mainly supported by corporate investors (Carrere, 2013). Some countries have land area under natural oil palm stands in traditional plantations while others have oil palm land where negotiations are underway or already completed (Carrere, 2013). Nigeria has the largest area under natural oil palm stands/traditional plantations followed by

Democratic Republic of Congo, Guinea and Togo. However, other countries like Angola, Burundi, Congo Republic, Equatorial Guinea, Ethiopia, Gabon, Gambia, Ghana, Guinea Bissau, Liberia, Madagascar, Mozambique, Sao Tome and Principe, Tanzania and Uganda either do not have estimated figures of land under traditional oil palm cultivation or do not have any area under traditional oil palm cultivation but land is negotiated or being negotiated for large scale industrial production (Carrere, 2013).

In Uganda, Oil palm cultivation began in 2005 in Bugala islands and was initiated by Vegetable oil development project (VODP) as an innovative public-private-producer-partnership (4P) approach based on a vertically integrated processor-nucleus estate smallholder mode (NOPP, 2017) and is in the process of being extended to other parts of the country including Masaka, Buvuma and Mayuge Districts. Adaptive trials are also conducted across the country in areas such as Bugiri, Kibaale and Kituza to test the environments for possible future expansion of commercial oil palm production. However, Uganda does not have a breeding program for oil palm. Therefore, improved oil palm varieties mostly hybrids are imported from South-East Asian countries, such as Malaysia and Indonesia and West African countries like Ivory Coast and Ghana. The Fresh Fruit Bunches (FFBs) are processed into Crude Palm Oil (CPO) by Oil Palm Uganda Limited (OPUL) and the company has effective Quality Management Systems (QMS) in place to make sure quality CPO is produced. Optimum harvesting cycle time and optimum minimum ripeness standard are normally established to ensure maximum oil content and acceptable levels of free fatty acid (FFA) in FFBs are maintained. However, these standards are based on the country from which the seedlings are imported, yet the environmental conditions in Uganda are quite different from the countries where breeding programs are established.

During the time of harvesting, in adaptive trials and different smallholder farmer blocks, a number of physiological disorders like bunch failure, bunch rot and un-even ripening have been reported (NOPP, 2017). These disorders cause high losses in yield worldwide, which culminate into great economic loss to oil palm industries including those in Uganda. Bunch failure may be caused by some herbicides, 'overbearing' and poor pollination (Corley and Tinker, 2016).

The incidence of bunch rot is unknown in Uganda. Two fungal species have been identified in causing bunch rot disease namely, *Marasmius palmivorus* and *Corticium rolfsii* with the former being the most destructive (Verheye, 2010). *Marasmius palmivorus* is primarily saprophytic on decaying organic matter. It becomes pathogenic in the presence of a large mass of dead or decaying organic matter. The threshold amount of inoculum necessary to cause disease is however not known and according to Aderungboye (1997), the disease is common under poor natural pollination. It begins as white strands of the mycelium covering the bunch surface which later penetrate the pericarp of the fruits causing wet rot of fruits. Affected fruits become soft then turn brown and black in color before rotting and drying off. Yield loss is both direct through rotting of bunches and indirect due to quality deterioration.

Quality loss results from increase in free fatty acid content of the fruits following infection and untimely harvesting. Improving sanitation, ablation, assisted pollination and fungicide application have been reported to reduce the adverse effect of this disease (Chung, 2011). Information on the occurrence of this disease on oil palm in Uganda is scanty. Such information is critical for effective management of the bunch rot disease. Similarly, uneven ripening resulting from imbalance in dry matter allocations because bunch sink requirements strongly increases in the last phase towards ripening as reported by Henson et al. (2008) is also well pronounced in oil palm farms in Uganda. This results in harvesting of half-ripe bunches which leads to poor fresh fruit bunch quality and high free fatty acid levels affecting oil palm profitability due to rejection of poor quality fruits at the factory (Woittiez et al., 2017). Bunch failure is also believed to be caused by poor natural pollination (Aderungboye, 1997) among other causes. However, like bunch rot and uneven ripening, the incidence level of bunch failure in Uganda is also not known and this curtails management options. Therefore, the aim of the study was to determine the incidence of uneven ripening, bunch failure and bunch rot and its severity as common physiological disorders on oil palm fruits so that effective management options can be sought and policy management guided on oil palm industrial expansion.

2. Materials and Methods

2.1 Study Area

The study was conducted in two agro-ecological zones of the Lake Victoria crescent where Buvuma, Bugiri and Masaka Districts are located and Lake Albert Crescent and western highlands ecological zone where Kagadi District is located. Buvuma is an island District located within Lake Victoria receiving a bi-model rainfall of 1178-1665 mm of rain with an average of 1363 mm per annum. The temperatures range from 22 ^{o}C to 24 ^{o}C (WeatherSpark, 2014). While, Masaka is located on the shores of Lake Victoria with annual rainfall ranging from 1100-1200 mm and an average of 1150 mm. The temperature varies from 15 to 30 °C (WeatherSparker, 2014). Bugiri District is also located on the shores of Lake Victoria receiving annually between 800-1500 mm of rainfall with an average of 1150 mm and temperature ranges between 16.7 to 30.6 °C.

Kagadi District on the other hand is located close to Lake Albert shores and receives between 1000 to 1540 mm of rainfall annually with an average of 1270 mm whose temperature ranges from 15 °C to 30 °C annually. The different smallholder farmer blocks (including; Kalangala, Kayunga, Bbeta west, Kagulube, Bbeta east and Bujjumba blocks) are located in Kalangala District. Kalangala District is surrounded by Lake Victoria in the South Eastern part of the country (Figure 1). It lies between longitudes 32°01′ East and 32°52′ East and latitudes 0°10′ and 1°00′ South. The District receives annual rainfall ranging between 1,125 to 2,250 mm with average maximum temperatures of 26 °C and average minimum of 17.5 °C (IFAD, 2012). It has two rainfall peaks between March and May and October and November.

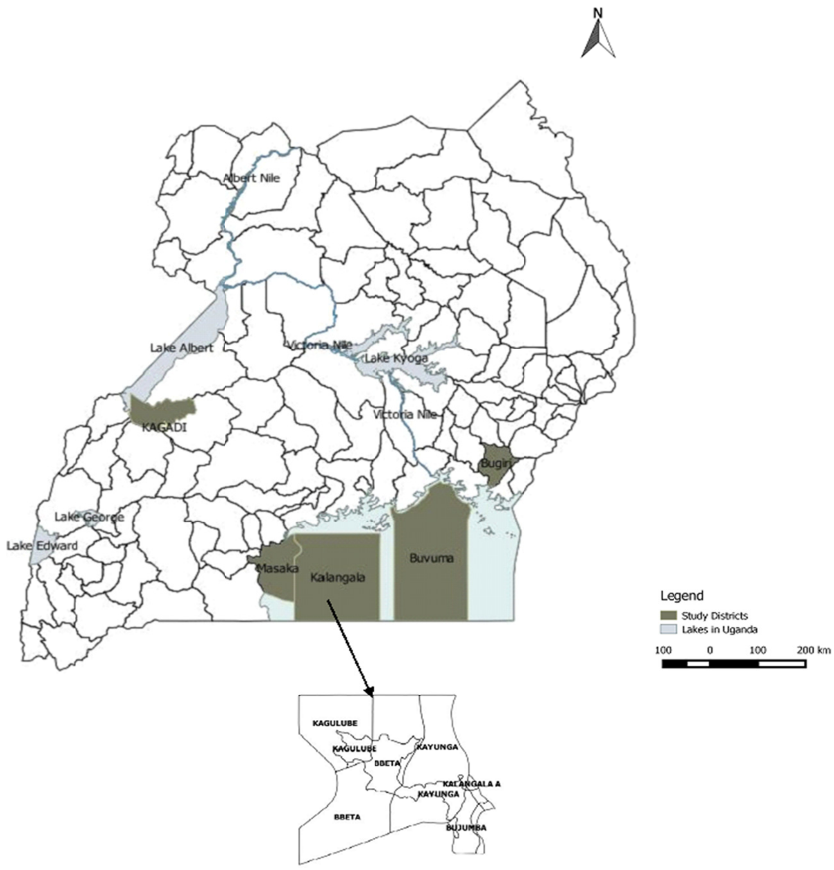

Figure 1. A map showing study Districts where sampling took place

2.2 Research Design

A survey based research design was used in which four adaptive research trials in four Districts were pre-selected together with six blocks in which the smallholder farmers are organized in Kalangala District. The survey did not involve collection of data from the nucleus estate of Oil Palm Uganda Limited (OPUL). Data taking was limited to bunch rot, bunch failure and uneven ripening which have been persistently reported by the farmers. The survey was conducted in two seasons, the dry season and the wet season. The survey in the dry season was carried out between the months of January and March and July to August, 2019 and the wet season was between the months of April to June and October to November, 2019. The data was collected on the physiological disorders that affect the oil palm fruit bunch.

2.3 Determination of Incidence of Bunch Failure, Bunch Rot and Uneven Ripening

Routine surveys were conducted in mature oil palm plantations > 5 years in smallholder farmer blocks in Kalangala and in adaptive trials established in Bugiri, Buvuma, Masaka and Kagadi Districts. Three fields each measuring at least one hectare were selected from each unit and three units were also selected from each block by the help of the extension officers of the Kalangala Oil Palm Growers' Trust (KOPGT). Palms in selected fields were randomly sampled and assessed for presence of bunch rot, bunch failure and uneven ripening symptoms in Kalangala while in adaptive trials since the plants are few, all plants were evaluated.

2.4 Determination of Severity of Bunch Rot

During the routine surveys which were conducted in mature oil palm plantations > 5 years in smallholder farmer blocks in Kalangala and in adaptive trials established in Bugiri, Mayuge, Buvuma, Masaka and Kagadi Districts, Palm trees were evaluated for the presence of bunch rot and its severity. The symptom expression of the bunch rot disease was scored as proposed by Chung (2011) with modifications on the scale of 0-4, where; 0 = health fruit bunch, 1 = strands of mycelium are seen on top of the fruit bunch, 2 = fruit bunch covered by many whitish mycelium and rhizomorphs, 3 = mycelium grow over the fruits and penetrate the mesocarp to produce a wet rot in light brown color, 4 = fruit bunch finally rots and abort due to *Marasmius* infection and secondary infection by other micro-organisms.

2.5 Data Analysis

Data on incidence were determined by counting the total number of affected oil palm fruit bunches and expressing it as a percentage of the total number of oil palm fruit bunches sampled. Data was subjected to analysis of varience and means were separated using the least significant difference method (LSD) at 5% level of significance. Data on severity of bunch rot disease was analysed by chi-square test among the different smallholder farmer blocks and adaptive trials between the two seasons. All statistical analyses were performed using Minitab version 17.1.0.Ink.

3. Results

3.1 Incidence of Bunch Rot in Four Adaptive Trials

A total of 1319 bunches were assessed for bunch rot in the adaptive trials in Bugiri District (334), Buvuma District (340), Kagadi District (358) and Masaka District (287). The means of bunch rot in the four Districts showed that Kagadi District had the highest number of bunches with bunch rot followed by Masaka District, Bugiri District, and Buvuma District respectively. The differences in the mean of bunch rot in the four Districts were statistically significant ($p < 0.05$) (Figure 2). This bunch rot was more pronounced during the wet season (17.4%) as compared to the dry season (8.37%) and the differences where statistically significant ($P < 0.05$).

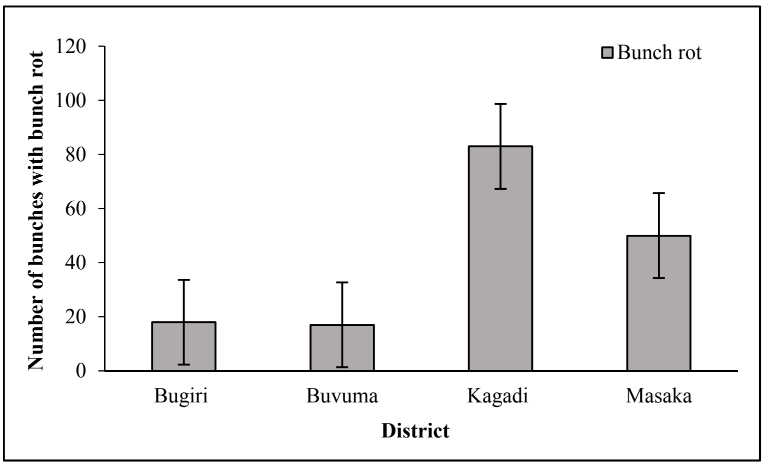

Figure 2. Tenera hybrids (origin: Ghana) with bunch rot in the different Districts.

3.2 Severity of Bunch Rot in the Adaptive Trials

Results showed that severity of bunch rot was highly associated with some Districts. For example Kagadi District had the highest number of bunches with bunch rot followed by Masaka District. They were also the two Districts with the highest number of bunches with the highest level of bunch rot severity (score 4). These differences in association were statistically significant ($p < 0.05$) (Table 1). The severity scores were strongly linked to wet season where many bunches showed a high level of bunch rot as compared to the dry season. A total of 111 bunches had bunch rot at different severity levels in the wet season as compared to 59 bunches sampled in the dry season. Bunch rot severity was highly associated with the wet season in the different Districts.

Table 1. Severity of bunch rot in Tenera hybrids (origin: Ghana) in the different Districts in the adaptive trials

Severity score	Districts				Total	df	χ^2	P
	Bugiri	Buvuma	Kagadi	Masaka				
0	316	323	273	236	1148	12	90.987	0.05
1	4	4	16	7	31			
2	6	10	21	12	49			
3	5	3	19	8	35			
4	3	0	28	24	55			
Total	334	340	357	287	1318			

Note. 0-Healthy fruit bunch, 1-Strands of mycelium are seen, 2-Fruit bunch covered by many whitish mycelium and rhizomorphs, 3-Mycelium grow over the fruits and penetrate the mesocarp to produce a wet rot in light brown color, 4-Fruit bunch finally rots and aborts due to Marasmius infection and secondary infection by other micro-organisms.

3.3 Incidence of Bunch Failure in Adaptive Trials

The survey of bunch failure showed that Masaka District had the highest number of bunches showing bunch failure, followed by Bugiri District, Kagadi District and Buvuma District. The differences in means of bunch failure in the four Districts were statistically significant ($P < 0.05$) (Figure 3). However, the bunch failure rate was not statistically significant between the two seasons.

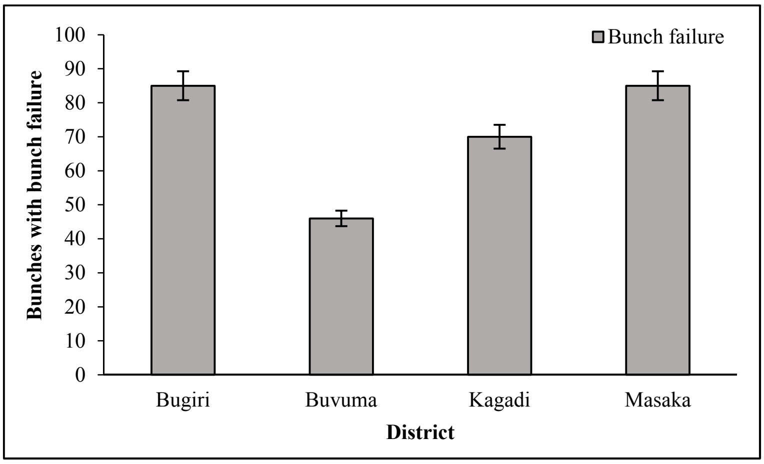

Figure 3. Tenera hybrids (origin: Ghana) with bunch failure across the four Districts in the adaptive trials

3.4 Incidence of Uneven Ripening in Adaptive Trials

A total of 1319 bunches were analyzed for uneven ripening in the adaptive trials in the four Districts of which Kagadi had the highest incidence of uneven ripening, followed by Bugiri, Buvuma and Masaka Districts (Figure 4). The differences in the means of bunches showing uneven ripening in the adaptive trials were not statistically significant and a similar trend was observed across the two seasons where there was no significant difference in the means between the wet (10.97%) and dry (10.28%) seasons.

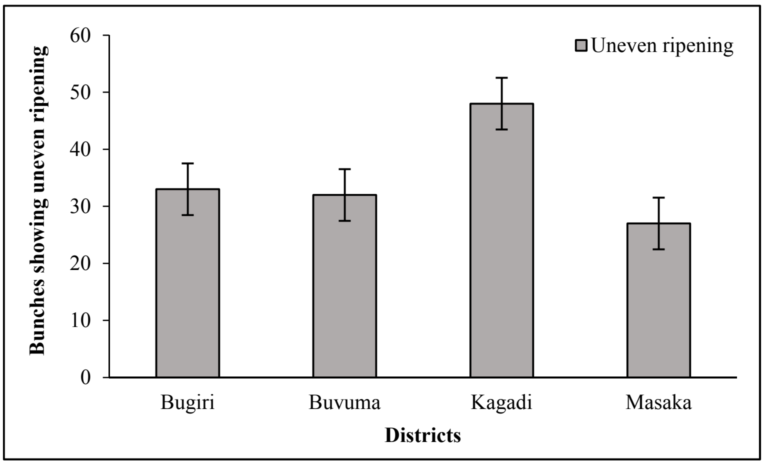

Figure 4. Tenera hybrids (origin: Ghana) with uneven ripening in adaptive trials in fur Districts

3.5 Incidence of Bunch Rot in the Different Smallholder Farmer Blocks in Kalangala District

A total of 4268 bunches were sampled for analysis of bunch rot in six smallholder farmer blocks under commercial oil palm plantation development. A total of 1126 bunches which were sampled in Kalangala block had the highest number of bunches with bunch rot followed by Kayunga (1045), Bbeta west (763), Kagulube (639), Bbeta east (462) and Bujjumba (233) (Figure 5) blocks respectively. These differences in the means of bunches showing bunch rot in the different farmer blocks in Kalangala were statistically significant (P = 0.004). During the wet season, the means of bunches with bunch rot was 2.37% of the 1099 bunches sampled while 1.58% of 3169 bunches sampled in the dry season had bunch rot. This difference in the means of bunch rot between the wet and dry season were not statistically significant (P = 0.09).

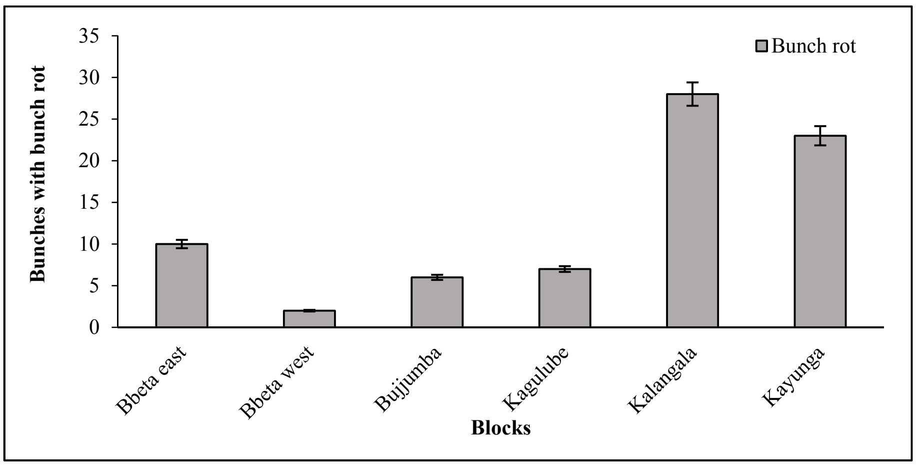

Figure 5. Tenera hybrids (origin: Ghana, Malaysia, Costarica and Indonasia) with bunch rot in six different smallholder farmer blocks in Kalangala

3.6 Severity of Bunch Rot in the Different Smallholder Farmer Blocks in Kalangala District

The severity of bunch rot was also highly associated with particular blocks. There were more bunches with bunch rot of different levels in Kalangala block followed by Kayunga, Bbeta east, Kagulube, Bujjumba and Bbeta west blocks. The differences in association of the severity levels with the blocks were statistically significant (χ^2 = 10.8, P = 0.03) (Table 2). This severity was also highly associated with the wet season with 2.366% bunches sampled showing bunch rot of different severity levels while 1.578% of bunches samples in the dry season showed bunch rot. The association of the bunch rot with season was statistically significant (χ^2 = 14.93, $P < 0.05$).

Table 2. Severity of bunch rot in the different smallolder farmer blocks of Tenera hybrids (origin: Ghana, Malaysia, Costarica and Indonasia) within Kalangala District

Severity score	Bbeta east	Bbeta west	Bujjumba	Kagulube	Kalangala	Kayunga	Total	df	χ^2	P
0	452	761	227	632	1097	1021	4190	4	10.79	0.029
1	0	1	0	0	2	4	7			
2	1	1	0	0	6	1	9			
3	4	0	4	1	11	5	25			
4	5	0	2	6	10	14	37			
Total	462	763	233	639	1126	1045	4268			

Note. 0-Healthy fruit bunch, 1-Strands of mycelium are seen, 2-Fruit bunch covered by many whitish mycelium and rhizomorphs, 3-Mycelium grow over the fruits and penetrate the mesocarp to produce a wet rot in light brown color, 4-Fruit bunch finally rots and aborts due to Marasmius infection and secondary infection by other micro-organisms.

3.7 Incidence of Bunch Failure in the Different Smallholder Farmer Blocks in Kalangala District

Results showed that 0.47% of the 3169 bunches sampled in the dry season showed bunch failure while 7.92% of the 1099 bunches sampled in the wet season showed bunch failure. This difference in the means of bunches showing bunch failure between the two seasons was statistically significant ($P < 0.05$). Across the blocks, Kagulube had the highest bunch failure rate followed by Kalangala, Kayunga, Bbeta west, Bujjumba and Bbeta east respectively (Figure 6). The differences in the means observed in the different blocks above were statistically significant ($P = 0.05$).

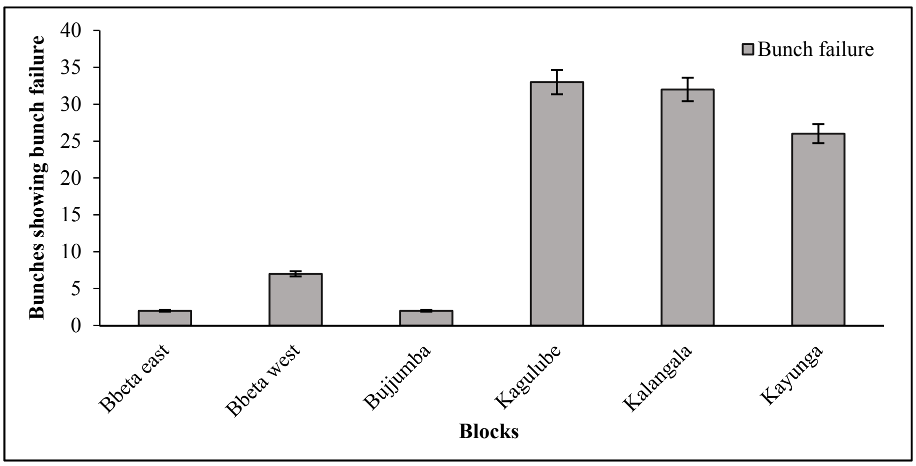

Figure 6. Tenera hybrids (origin: Ghana, Malaysia, Costarica and Indonasia) with bunch failure in six different smallholder farmer blocks in Kalangala District

3.7 Incidence of Uneven Ripening in the Different Smallholder Farmer Blocks in Kalangala District

A total of 4268 bunches were sampled to determine uneven ripening in the different smallholder farmer blocks in Kalangala District. Kayunga block had the highest number of bunches with uneven ripening. This was followed by Kalangala block, Bujjumba block, Bbeta east, Bbeta west and Kagulube block respectively. These differences in the means of bunches showing uneven ripening in the different blocks were statistically significant ($P = 0.05$). Across the two seasons, 9.75% of 3169 bunches sampled in the dry season had uneven ripening while 18.56% of 1099 bunches sampled in the wet season had uneven ripening. Figure 7 shows that the difference in means of bunches showing uneven ripening was also statistically significant at $P = 0.05$.

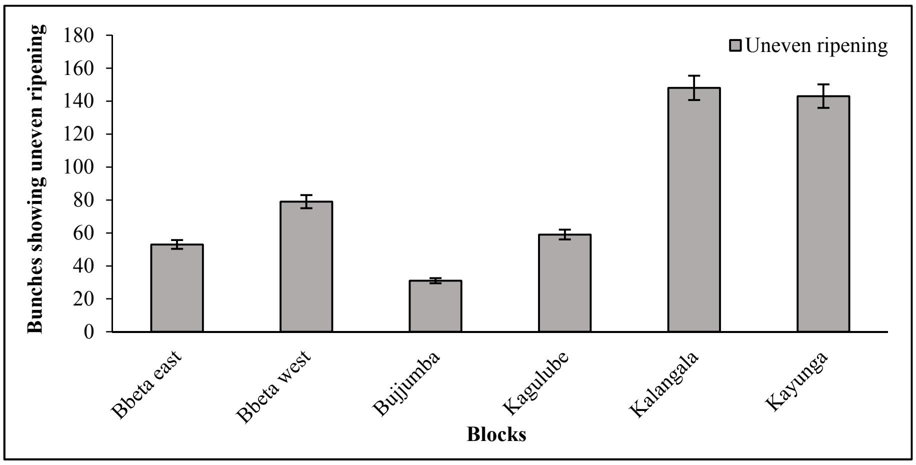

Figure 7. Tenera hybrids (origin: Ghana, Malaysia, Costarica and Indonasia) with uneven ripening in six farmer blocks in Kalangala District

4. Discussion

4.1 Incidence and Severity of Bunch Rot in the Adaptive Trials

There was a high incidence of bunch rot in the adaptive trial in Kagadi District which is attributed to the high amount of debris and detritus which was so much in the field during the time of bunch sampling. The palms were not sufficiently pruned as compared to trials in other Districts and the ripe fruits were also not harvested on time (unpublished data). The findings of accumulation of debri causing bunch rot are similar to what has been reported by Turner and Bull (1967) who stated that sanitation is one of the key factors influencing bunch rot disease development. Additionally the cold conditions of Kagadi District exacerbated the bunch rot disorder, since it has been shown that the disease is so prevalent under cold conditions (Aderungboye, 1997). The high bunch rot which was observed in Masaka District albeit the slightly warm conditions could be due to poor pollination which resulted in a high degree of bunch failure. Poor pollination results into poor fruitset which increses the amount of debris serving as a platform for proliferation of *Marasmius palmivora*. The high incidence of this disease in Masaka District is in line with reported diseases of other horticultural crops like watermelon and pumpkins (Masika et al., 2017). The soils in Masaka where the adaptive trial is located are dominant in clay and this might have contributed to causing considerable fungal infection among bunches. According to Chung (2011), bunch rot may also occur due to severe deficiency of potassium and magnessium. Severity of bunch rot similarly followed a similar trend being highest in Kagadi, Masaka Bugiri and Buvuma. The observed incidence and severity of bunch rot in other Districts like Bugiri and Buvuma is highly attributed to poor sanitation in wet seasons like limited pruning and untimely harvesting (Turner & Gillbanks, 2003).

4.2 Incidence of Bunch Failure in Adaptive Trials in the Four Districts

Bunches which failed to develop from anthesis to harvest were observed in the adaptive trials. Bunch failure is believed to be caused by incomplete pollination which results in poor fruit set and eventually yield loss (Harun & Noor, 2002). Incomplete pollination may therefore be responsible for bunch failure in Masaka, however, further studies are required to ascertain this observation. Furthermore, the soil type of the adaptive trial in Masaka which equally showed the highest degrees of bunch failure is mainly clay which forms a hard cake/pan in the dry season leading to low moisture levels and thus, bunch failure. According to Corley and Tinker (2016), the fluctuations in pH of clay affects growth of palms which negatively impacts on fruit set. The poor soils observed in Masaka (data not reported) possibly led to low photosynthetic rates and thereby affecting buildup of assimilates (Corley & Tinker, 2016) resulting in bunch failure. Additionally, water deficit which leads to low photosynthetic rate may be responsible for bunch failure in the adaptive trial in Bugiri. This is corroborated by a study by Danso (2008), who stated that there is an inverse relationship of water deficit and oil palm yield in Ghana.

4.3 Incidence of Uneven Ripening in Adaptive Trials in the Four Districts

There was a high degree of uneven ripening in Kagadi followed by Bugiri, Masaka and Buvuma. The variations in climate on yield components of oil palm are complex for example, the drought period on yield occur with long time-lags. Uneven ripening is one of the factors that affect yield and is believed to be as a result of long anthesis period (Harun & Noor, 2002). Although Kagadi District is located in a relatively fertile area with sufficient rainfall in the rain season, one adaptive trial is located on a slightly dry area with hardpans (rocks). This means that the poor soils coupled with high temperatures in the dry season may be responsible for the uneven ripening observed in this area this is in line with what was observed by Harun and Noor (2002). Masaka and part of the adaptive trial in Bugiri, are located on dominant clay soils which pans in the dry season. This results in imbalance in dry matter allocations because bunch sink requirements strongly increase in the last phase towards ripening as reported by Henson (2008) and the variations lead to uneven ripening. Similarly, the high temperatures which are experienced in the dry spell may be responsible for the reduction in the numbers of pollinator weevils which also results in poor fruit set which in the long run result into uneven ripening. This is similar to wat was reported by Woittiez et al. (2017).

4.4 Incidence and Severity of Bunch Rot in the Different Smallholder Farmer Blocks in Kalangala District

There was generally low incidence of bunch rot in the different farmer blocks in Kalangala. In the order of decreasing bunch rot, incidence and severity were highest in Kayunga > Kalangala > Bbeta east > Bujjumba > Kagulube > Bbeat west. The low incidence of bunch rot in the different smallholder farmer blocks in Kalangala may partly be due to the high degree of sanitation and timely harvesting that was observed in the plantations during the sampling time. These findings are similar to what was reported by Chung (2011) that good sanitation is key in reducing bunch rot. However the few identified cases could be linked to poor nutrition of the oil palm trees in some fields as there is no recommended fertilizer management strategy for palm oil farmers in Uganda (NOPP, 2017). According to Corley and Tinker (2016), poor nutrition results in poor fruit set. The bunch rot observed at low level in Kalangala District may also be due to environmental factors such as seasonal changes in rainfall, photoperiod and drought which directly affect carbon assimilation and survival of pollinator weevils. These factors lead to inefficient pollination and sometimes acute and severe shortage of assimilates caused by lack of water or radiation (Combres et al., 2013). Inefficient pollination results into bunch failure and accumulation of wastes forms a good ground for survival of *Marasmius palmivorus*.

4.5 Incidence of Bunch Failure in the Different Farmer Blocks in Kalangala

Bunch failure was not so pronounced in the different smallholder farmer blocks although, it was highest in Kagulube with 5.16%. The low percentage occurance may be attributed to the optimal conditions of finely structured soils with loam and silt-dominated soils (Pirker et al., 2016). Furthermore, oil palm being a heavy feeder crop requires large quantities of minerals like potassium, as well as nitrogen, phosphorus, magnesium, and boron (Broeshart et al., 1957). Eventhough the soil conditions are yet to be determined, the Kalangala Islands still support good growth and productivity of oil palm. There were generally few bunch abortions before full ripening or after anthesis observed during the survey. This is consistent with what has been reported by other researchers elsewhere (Sparnaaij, 1960; Dufour et al., 1988; Caliman & Southworth, 1998; Nouy et al., 1999). The observed Bunch failure incidence of 5.16%, 2.84%, 2.49% are similar to what was reported by Sparnaaij (1960) 25%. The observed incidence of bunch failure could be attributed to poor pollination which results in poor fruit set and therefore bunch failure (Corley & Tinker, 2016).

4.6 Incidence of Uneven Ripening in Different Farmer Blocks in Kalangala District

The incidence of uneven ripening was high in the different smallholder farmer blocks with all the locations having incidence of > 1% of the palm trees sampled except Bbeta west which had an incidence of uneven ripening of 0.92%. There was a high incidence of uneven ripening in the wet season compared to the dry season. These results are supported by what has been reported by Henson (2008), who asserts that temperature plays a key role in plant metabolism and dry matter relocation. The temperatures in Kalangala most especially in the wet season are less than the optimal range of minimum temperature (22-24 °C) and maximum temperature range (between 29 and 33 °C) (Woittiez et al., 2017). This affects dry matter allocation and thus, affects uniform ripening. The observed incidence of uneven ripening may also be attributed to incomplete pollination resulting from low numbers of pollinator weevils which leads to poor fruit set and uneven ripening (Corley & Tinker, 2016).

5. Conclusion and Recommendations

The study identified physiological disorders in oil palm fruit bunches in Uganda. Among the physiological disorders, uneven ripening showed a significantly higher incidence in the different smallholder farmer blocks in Kalangala District. In the adaptive trials, the difference in uneven ripening was not statistically significant but other disorders such as bunch rot and bunch failure were significant and this calls for further investigation into uneven ripening to understand the factors perpetuating its existence. For example, what would be the effect of temperature changes on uneven ripening because it has been reported that temperatures below 22 ^{o}C reduces the rate of photosynthesis and thus, affecting allocation of photosynthates. Investigation will also be needed on the pathogenicity of the fungus causing bunch rot and other bad agronomic management practices which hasten the occurance of these physiological disorders so that management options can be designed to bring them under control.

This study also sets the platform to determine water deficit at the various ecological zones and its relationship to physiological disorder as a guide for further oil palm estate development. It is recommended that this study is upscaled to other oil palm growing areas in Uganda

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