PREDISPOSING FIELD FACTORS TO *CARICA PAPAYA* L FRUIT ROTS

Louis Egwari, Margaret Oniha

Department of Biological Sciences, Covenant University, Ota, Nigeria

Abstract

Carica papaya L is famous for its latex and succulent vitamin rich fruit. However, the plant has little commercial value compared with citrus and mango possibly as a result of its many associated diseases. In this experiential study we determined field factors associated with C. papaya fruit rots. A three and half year observational study in a model research and demonstration farm revealed the following as significant to papaya fruit rot; plants >2 years were more susceptible to diseases, infection particularly fungal was predominant in late dry season (February to March) which also coincided with the tailing period of harvest. Insects mostly beetles, mulluscs (snails and slugs) and millipedes were prevalent pests in wet months and served as vectors for spread of disease or inflicted mechanical damage on the plant parts especially on fruits. Vegetation management had significant impact on the spread of diseases as it determined the prevalence of pests and disease-associated weeds. Powdery mildew and apical necrosis were typical of dry months (November to March), anthracnose occurs more often with onset of rain accompanied with wind while other disease conditions were prevalent in the wet months (August to October). Infected stems and leaves constituted the reservoirs of spoilage organisms.

Keywords: *carica papaya, fruit rots, predisposing field factors, weather, plants age*

1. INTRODUCTION

Mature green and ripe papaya contains more vitamin A than carrots, more vitamin C than oranges and mango, abundant vitamin B factors and vitamin E (Tietze, 2002; Samson 1986). Though antifungal and antibacterial properties of the milky latex and seeds have been reported (Giordani and Siepai, 1991; Emeruwa, 1982) the fruit high content of water (86.8%) and carbohydrate (12.2%) (Awoite et al. 2013; USDA, 2005; Ray, 2002) makes it especially susceptible to microbial degradation (Nishijima, 1994). The disease severity of papaya may be so serious that an entire orchard may be affected (Koffi et al. 2010; Diallo et al. 2008; Ventura et al. 2004). Where proper farm management practices are not maintained the infecting organisms may persist in the orchard and constitute inoculums for new stands introduced into the field (L. O. Egwari, personal observation). Primarily microbial spoilage accounts for a greater proportion of poor yield and post-harvest losses of papaya there are underlining aggravating factors; both pre- and postharvest. The magnitude of these factors and their interplay in defining the health of *C. papaya* orchard and harvest quality may differ from country to country or from one geographic condition to another.

Fungi have been described as major field pathogen of *Carica papaya* L. though virus, arthropods and other vectors may play significant roles in disease process and distribution. For instance papaya meleira virus transmission has been linked with the whitefly, *Trialeurodes variabilis* (Picaço et al. 2003; Culik et al. 2004) however, experimental data on vector role of the whitefly remains contentious (Rodriques et al. 2009; Vidal et al. 2000). In addition, non-biological agents which are invariably associated with farm practices such as harvesting techniques (conventional versus mechanized), soil nutrient composition and seasonal variability may facilitates entry of pathogens into fruits (Rodrigues et al. 2009; Snowdon, 1990; Bulit and Dubos, 1988). An overriding factor in disease transmission in orchards is weather condition; rainfall, temperature and wind. Diseases transmission associated with weather may not be apparent before harvest but predispose to post-harvest symptoms (Conway, 1984).

Weather conditions have accounted for types and severity of *C. papaya* diseases in the field and this also translate to post-harvest losses. In one study in India (Singh *et al*., 2012), *Aspergillus flavus* was prevalent during the rainy season of July to October, while *Fusarium moniliforme* accounted for the bulk of spoilt fruits in winter (November to February). Temperature and relative humidity as a

component of weather have been described to have their effect on papaya fruit health. Microbial activities are maximal at temperature of 30-35 ^{o}C and RH of 80% (Singh and Sumbali, 2007; Baiyewu and Amusa, 2005; Lukose and Singh, 1997). Though a number of studies describing the microbial aetiology of fungal diseases pre- and post-harvest can be found in the literature, none from Nigeria has addressed the field factors essential for the development and spread of papaya fruit rots. This study was carried out with a view to proffer measures for control of papaya fruit rots in the field through understanding of factors that predispose to disease transmission.

2. METHODS

2.1. The pawpaw research and demonstration farm

The farm was first cultivated in 2009 following the successful production of Pawpaw beverages and the grant of patent for beverage production from pawpaw fruit. The demonstration farm known as Covenant University Pawpaw Research Farm was setup to both multiply special hybrids of *C. papaya* (Solo; Sunset, Kapoho cultivars and cylindrical elongated yellow to red variety weighing between 6 and 10 kg) and to understudy papaya diseases with the objective of integrating disease prevention and control measures. The farm now renders extension service to prospecting and start-up farmers and also serves as a platform for experiential learning.

2.2. Disease description and prevalence

A systematic field survey of the *C. papaya* rot diseases was carried out on the farm from September 2010 until March 2014. The Farm was visited minimum 3 days in a week and the following data recorded: the geographical location of the Farm (longitude and latitude) using GPS device (SILVA); Rainfall, RH, Temperature, and Wind Velocity. Averages of these values across the prevailing climate season in Nigeria were recorded. Disease prevalence was studied both in the wet and dry seasons. Factors contributing to diseases of the fruit, leaf and stem were determined and described. The numbers of fruiting *C. papaya* stands were counted and diseased plants were defined as plants with obvious visual spoilage symptoms.

2.3. Role of weather on type and prevalence of disease

Wet and dry seasons constitute the major weather condition of the farm all through the year. The wet season spans from April to early November. The dry season starts late November to March with sparse and periodic rainfall. The type and prevalence of disease in *C. papaya* during these seasons were determined.

2.4. Effect of age on disease susceptibility

Only plants that have passed through one fruiting season were studied. Two fruiting seasons were considered. Plants yield and disease susceptibility with age was determined. Number of stands with fruit, leaf and stem diseases were counted.

2.5. Role and seasonality on vectors' preponderance

The role played by vectors in *C. papaya* diseases were studied in relation to factors that determine their preponderance. The vectors studied included the African giant snail, slugs, leafhoppers, beetles, aphids, ticks and mites. Periodicity of these vectors was studied and their relationship to prevalent diseases determined. Frequency of weeding, use of herbicides and pesticides impact on the prevalence of these vectors in the farm was determined.

3. RESULTS AND DISCUSSION

Table 1 shows decline in number of fruiting stands on farm and average number of fruits borne on a tree from the period 2011-2012 to the period 2013-2014. Reciprocally, as the plants aged the number of stands with fruit rots increases and increasing number of spoilt fruits per stand. In summation, the percentage of infected stands in the 2 year study period showed significant rise in infected stand with

age of plants on the farm ($P \leq 0.001$). These observations account for while *C. papaya* though a perennial is cultivated as annual by many farmers (Teixeira da Silva et al. 2007). Considering it takes approximately 10-14 months for first fruiting and an additional 3-5 months for harvest (Teixeira da Silva et al. 2007; Rodrigues and Galán, 1995), the annual maintenance of farm should take this first bloom into account in modeling farm practice. The data on the ratio of rot to healthy fruits per tree was 1:4 representing 25 % fruit rot during rain in 2011 and 1:2 (50 %) in 2013. Thus disease rather than nutrient availability is critical to the viability of *C. papaya*. Therefore control measures against *C. papaya* field diseases should be intensified. Once a field is infested by pest or microbes it is usually more economical to replace the farm with new crops than to apply field treatment which in most cases have not yielded the desirable results. This is associated with the diversity of pest and diseases of *C. papaya*. For instance, over 39 arthropods have been reported to infest papaya despite its many microbial pathogens (Singh, 1990) and each requiring different treatment regimen.

Table 1. Effect of climatic conditions on *C. papaya* fruit rots

Age of Plant	Season of Survey	No. of Fruiting Stands (av. fruits/stand)	No of Stands with Fruit Rot (av. No. of fruit with rot)	% of Stands Infected	Ratio of Rot to Healthy Fruits
2 years (2nd harvest season)	2011-2012				
	Apr-Aug, 11	50 (8)	7 (2)	14.0	1:4 (0.25)
	Sep-ENov, 11	190 (18)	19 (3)	10.0	1:6 (0.17)
	LNov,11-Jan, 12	210 (12)	25 (5)	11.9	5:12 (0.42)
	Feb-Mar,12	210 (10)	25 (5)	13.3	1:2 (0.50)
3 years (3rd harvest season)	2013-2014				
	Apr-Aug, 13	32 (6)	10 (3)	31.3	1:2 (0.50)
	Sep-ENov, 13	105 (15)	42 (7)	40.0	7:15 (0.47)
	LNov,13-Jan, 14	115 (10)	48 (5)	41.7	1:2 (0.50)
	Feb-Mar,14	115 (10)	53 (5)	46.1	1:2 (0.50)

ENov; Early November, LNov; Late November, av; Average

Disease preponderance was influenced by season with highest incidences in the dry months and this co-related with period of wind and low humidity (data not shown). Though *C. papaya* fruit all year round in Nigeria, peak harvests are from November to February. Conventionally, heavy rainfall ceases in October; there may be sporadic down pour in early November and December. These late rainfall usher the Hamattan (dry season) which is usually cold, humid and later dry and windy with temperature fluctuating from extreme cold (12-17 ^{o}C) in the early hour of the day and reaching 34 ^{o}C in the afternoon and may fall again in the evening time and at night to between 19 and 22 ^{o}C. *Carica papaya* is sensitive to extremes of weather conditions as in frost; growth occurring best at latitudes 32′ N and S (Litz, 1984) with optimal growth at 22-26 ^{o}C and evenly distributed rainfall of 100-150 cm and good exposure to sunlight (Samson, 1986). Pests' abundance (molluscs, arthropods and millipedes) in the farm during wet months decline as the dry season sets in. Pest preponderance may be associated with the rich vegetation within and around the farm. Interestingly, fewer disease incidences were recorded in the farm pre-peak papaya harvest. A plausible explanation is that disease

transmission might have occurred and only became manifest when the fruits have reached maturity and ready for harvest. This is understandable as some healthy looking fruits hand picked got spoilt within few days postharvest. The role of these pests in disease transmission in this study was circumstantial and may at best serve as mechanical vectors or their secretions and activities may weaken the cuticle thereby predisposing to infection with infectious agents (Teixeira da Silva et al. 2007; Morton, 1987). For example, the papaya web worm predisposes to infection with *Colletotrichum gloeosporioides* which later appears as postharvest disease (Aires *et al*., 2004). The rains preceding the dry season are usually heavy resulting in run-off and over-flooding. These carry disease agents from far and couple with the depletion of nutrient due to erosion the plants are prone to the double barrel of nutrient deficiency and availability of infectious agents. It is therefore essential to apply treatment to the farm prior to harvest. The proper timing of this may help conserve harvest that could have been loss to nutrient deficiency and disease.

Table 2. Seasonal prevalence of *C. papaya* leaf disease

Age of Plant	Season of Survey	Disease*	No. of Stands Infected	Co-relation between Leaf and Fruit Rots
2 years (2nd harvest season)	2011-2012			
	Apr-Aug, 11	Watery soft rot	11	1.0
		Stem end rot		0.52
	Sep-ENov, 11	Watery soft rot	24	
		Stem end rot		
	LNov,11-Jan, 12	Anthracnose		1.1
		Stem end rot	27	
		Anthracnose		
	Feb-Mar,12	Black rot	35	0.88
		Powdery mildew		0.62
		Stem end rot		
		Black rot		
		Powdery mildew		
3 years (3rd harvest season)	2013-2014			
	Apr-Aug, 13	Watery soft rot	15	1.0
		Stem end rot		0.54
	Sep-ENov, 13	Watery soft rot	48	
		Stem end rot		
	LNov,13-Jan, 14	Anthracnose		0.74
		Stem end rot	55	
		Anthracnose		
	Feb-Mar,14	Black rot		0.68
		Powdery		0.90

		mildew Stem end rot Black rot Powdery mildew	61	

*major fungal aetiologies: *Colletotrichum* (watery soft rot, stem end rot, anthracnose); *Rhizopus* (watery soft rot); *Fusarium* (stem end rot); *Phytophthora* (stem end rot); *Aspergillus* (black rot); *Oidium caricae* (powdery mildew).

Table 3. Prevalent *C. papaya* stems diseases in wet and dry seasons

Age of Pant	Season of survey Season of survey	Disease	No. of Stands Infected	Co-relation between Stem and Fruit Rots
2 years (2nd harvest season)	2011-2012 **Apr-Aug, 11** **Sep-ENov, 11** **LNov,11-Jan, 12** **Feb-Mar,12**	Stem node rot* Powdery mildew Stem node rot Black rot Stem node rot Powdery mildew Black rot Powdery mildew	9 20 25 30	0.43 0.54 0.77
3 years (3rd harvest season)	2013-2014 **Apr-Aug, 13** **Sep-ENov, 13** **LNov,13-Jan, 14**	Stem node rot Stem canker Stem node rot Black rot Powdery mildew Stem canker	11 40 51	0.53 0.63 0.76

	Feb-Mar,14	Stem node rot Black rot Powdery mildew Stem canker Stem node rot Black rot Powdery mildew Stem canker	58	

*aetiologies for stem node rot (*Colletotrichum*, *Fusarium*, *Phytophthora*)

Wind velocity is relatively high during the tailing period of the wet season and the onset of the dry season and makes dispersal of fungal spores more efficient. Also, the high temperature which average 34 ^{o}C (upper temperature range) and low rainfall further weaken plants' vigor and subject them to microbial attack (Tables 2 and 3). Fungi isolated in association with the diseases prevalent in the farm were *Colletotrichum gloeosporioides* (watery soft rot, stem end rot, anthracnose); *Rhizopus stolonifer* (watery soft rot); *Fusarium* (stem end rot); *Phytophthora palmivora* (stem end rot, phytophthora blight); *Asperisporium caricae* (black rot); *Oidium caricae* (powdery mildew). The symptomatology and economic importance of these C. papaya pathogens are reviewed elsewhere (Bautista-Baños *et al*., 2013; Teixeira da Silva et al. 2007). The period late November through March recorded more disease type in the farm. The co-relation between leaf and fruit rots is higher compared with that between stem and fruit rots indicating that fruits are more likely to be infected from the leaves Tables 2 and 3). However, stem end rot originated from infected stem on which fruits are in contact.

In conclusion, this study has shown the role played by various factors in contributing to the health of C. papaya orchard. While the non-climatic factors can be relatively controlled, climatic factors may require more innovative approach. It is however evident from this study and others that pre-harvest factors will significantly determine the shelf-life and marketability of *C. papaya* fruit either for domestic consumption or export.

REFERENCES

Aires, VJ Cost, H and da Silvia, JL 2004, Papaya diseases and integrated control, In: Naqvi, .A.M.H. (ed.), *Diseases of Fruits and Vegetables: Diagnosis and Management*, vol. II. Kuwier Academic Publisher, Netherlands, pp.201-268.

Awoite, TM, Olorunfemi, MF, Ajani, AO and Oyelakin, MO 2013, Studies on fungi associated with post harvest spoilage of pawpaw *Carica papaya* fruit, *Journal of Pharmacy and Biological Sciences*, 4: 01-04.

Baiyewu, R and Amusa, NA 2005, The effect of temperature and relative humidity on papaya fruit rot in south-western Nigeria, *World Journal of Agricultural Sciences*, 1: 80-83.

Bautista-Baños, S, Sivakumar, D, Bello-Perez, A, Villanueva-Arce, R and Hernandez-Lopez, M 2013, A review of the management alternative for controlling fungi on papaya fruit during the postharvest supply chain, *Crop Protection*, 49: 8-20.

Bulit, J and Dubos, B 1988, Botrytis bunch rot and blight, In: RC Pearson and AC Goheen (eds) *Compendium of Grape Diseases*, APS Press, St Paul MN, pp. 13-15.

Conway, WS 1984, Preharvest factors affecting postharvest losses from disease In: HE Moline (ed) *Postharvest Pathology of Fruits and Vegetables: Postharvest Losses in Perishable Crops*, Univ. Calif., Agric Exp Sta Bull No 1914 (Pub NE-87), pp. 11-16.

Culik, MP and Martins, DS 2004, First record of *Trialeurodes variabilis* (Quaintence) (Hemiptera: Aleyrodidae) on *Carica papaya* L. in the state of Espirito Santo, Brazil, *Neotropical Entomology*, 33: 659-660.

Emeruwa, AC 1982, Antibacterial substance from *Carica papaya* fruit extract. *Journal of Natural Products* 45: 123-127.

Giordani, R and Siepai, OM 1991, Antifungal action of *Carica papaya* latex isolation of fungal cell wall hydrolyzing enzymes, *Mycoses*, 34: 469-477.

Diallo, HA, Monger, W, Kouassi, N, Yoro, TD and Jones, P 2008, Occurrence of Papaya ringspot virus infecting papaya in Ivory Coast, *Plant Viruses*, 2: 52-57.

Koffi, CNB, Diallo, HA, Kouadio, JY, Kelly, P, Buddie, AG and Tymo, LM 2010, Occurrence of *Pythium aphanidermatum* root and collar rot of papaya (*Carica papaya* L.) in Côte d'Ivoire, Fruit, Vegetable and Cereal Science and Biotechnology, 4:62-67.

Litz, RE 1984, Papaya, In: Sharp WR, Evans DA, Ammirato PV, Yamada Y (eds), *Handbook of Plant Cell Culture* (Vol2) MacMillan Publishing Co., NY, pp. 349-368.

Lukose, C and Singh, RD 1997, Climatic factors affecting the severity of pomegranate fruit rot. *Journal of Mycology and Plant Pathology*, 27: 48-50.

Morton, JF 1987, Papaya, In: Morton, JF (ed.), *Fruits of Warm Climates*, *Creative Resource Systems*, Inc., Miami, FL, pp. 336-346.

Nishijima, W 1994, Papaya, In: Ploetz RC (ed.), *Compendium of Tropical Fruit Diseases*, American Phytopathological Society, St. Paul, MN, pp. 54-70.

Picaço, MC, Moura, MF, Moreira, MD and Antonio, AC 2003, Biologia, identificação e manejo de moscas-brancas emfruteiras.In:Zambolim L (ed.), *Manejo Integrado, Produção integrda, Fruteiras Tropicais, Doenças e Pragas*, pp. 243-284, UVS Publisher, Viçosa, Brazil.

Ray, PK 2002, *Breeding Tropical and Subtropical Fruits*, Narosa Publishing House, New Delhi, pp.106-128.

Rodriques, SP, Andrade, JS, Ventura, JA, Lindsey, GG and Fernandes, PMB 2009, Papaya meleira virus is neither transmitted by infection at wound sites nor by the whitefly *Trialeurodes variabilis*, *Journal of Plant Pathology*, 91: 87-91.

Rodrigues, MC, Galán V 1995, Preliminary study of paclobutrazol (PP333) effects on greenhouse papaya (*Carica papaya* L.) in the Canary Islands. *Acta Horticulturae*, 370:167-172.

Samson, JA 1986, Mango, avocado and papaya, In: *Tropical Fruits*, Longman Scientific Inc., New York, pp. 185-221.

Singh, I 1990, *Papaya*, Oxford and IBH Publishing Co. Pvt Ltd, New Delhi, 224 pp.

Singh, YS and Sumbali, G 2007, Management of *Penicillium expansum* rot of apples by lactic acid bacteria, *Annals of Plant Protection Science*, 15:399-401.

Singh, P, Mishra, AK and Tripathi, NN 2012, Assessment of mycoflora associated with postharvest losses of papaya fruits, *Journal of Agricultural Technology*, 8: 961-968.

Snowdon, AL 1990, *Color Atlas of Post-Harvest Diseases and Disorders of Fruits and Vegetables*, Vol. 1, General Introduction and Fruits. CRC Press, Boca Raton FL.

Teixeira da Silva, J.A, Rashid, Z, Nhut, DT, Sivakumar, D, Gera, A, Souza Jr, MT et al 2007, Papaya (*Carica papaya* L.) biology and biotechnology, *Tree and Forestry Science and Biotechnology*, 1:47-73.

Tietze, HW 2002, *Health and Fitness* Harald W, Tietze Publishing Property Limited, Bermagui.

USDA National nutrient database for standard references, release 18 (2005) Available online http://www.nal.usda.gov/fnic/foodcom/search/

Ventura, JA, Costa, H and da Silva Tatagiba, J 2004, Papaya diseases and integrated control, In: Naqvi SAMH (ed.), *Diseases of Fruits and Vegetables* (Vol II). Kluwer Academic Publishers, The Netherlands, pp 201-268.

Vidal, CA, Nascimento, AS, Barbosa, CJ, Marques, OM and Habibe, TC 2000, Experimental transmission of “sticky disease” of papaya by *Bemisa argentifolii* Bellows & Perring. *In International Congress of Entomology*, Foz do Iguaca-PR, SEB/EMBRAPA, 2000, Abstract Book 2, 819.