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Severity of *Phytophthora* leaf blight disease and susceptibility of two local varieties of *Colocasia* to *Phytophthora colocasiae* Raciborski in Nsukka zone of South Eastern Nigeria

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Abstract

Leaf-blight disease of *Colocasia* caused by *Phytophthora colocasiae* Raciborski has been a serious impediment to cocoyam production in Nigeria. Disease severity and susceptibility of the two most cultivated local varieties "Ugwuta" (*Colocasia esculenta* var. *antiquorum*) and "Nkashi *Colocasia esculenta* var. *esculenta*) were investigated. Disease severity was visually estimated as the percentage leaf surface affected by blight, lesion or lesion-related chlorosis for each leaf of a plant using a seven-point scale of 0, 5, 10, 25, 50, 75 and 100% in three locations: Ede-Oballa, Nsukka Urban and Obukpa. Susceptibility was assessed on 2 months old potted plants of each variety inoculated with a 7-day old culture of *P. colocasiae.* Diameters of lesions on inoculated leaves were recorded from the 3rd - 8th day after inoculation. Data on severity were subjected to ANOVA and susceptibility of the varieties was compared with t-test. Results revealed significant LSD=4.96 (0.05) and varying degrees of leaf blight severity among varieties and locations. Variety *antiquorum* had significantly higher severities of 42.08, 46.40 and 47.42% at Ede-Oballa, Nsukka Urban and Obukpa respectively, compared to 34.85, 36.55 and 28.19% recorded by var. *esculenta* at these locations, respectively. Similarly, var. *antiquorum* had greater lesion diameter ranging from 0.65±0.07 cm - 3.70±0.14 cm and average diameter of 2.4±0.16cm compared to var. *esculenta* which had 0.41±0.14cm - 3.12±0.19 cm and average diameter of 1.80±0.16. This research has shown that varieties and locations affect the severity and susceptibility of *Phytophthora* leaf blight disease. This could be a guide to farmers having known that var. *esculenta* is less severe to *Phytophthora* leaf blight disease.

Keywords: Leaf-blight, *Colocasia,* Severity, Susceptibility, Cultivars, *Phytophthora*

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INTRODUCTION

Taro (*Colocasia esculenta* (L.) Schott) is a herbaceous perennial plant in the sub-family Colocasioideae of the monocotyledonous Aroids. Its shoot system consists mainly of leaves with long succulent petioles borne in whorls at the apex of an underground stem commonly known as corm, which is the main storage organ. The lower part of the corm gives rise to numerous roots and in some cultivars, produces many cormels from its axillary buds. The corms and cormels contain highly digestible carbohydrates (Aboubakar *et al*., 2008; Alcantara *et al*., 2013) and constitute essential staple food in Nigeria (Amusa *et al*., 2011; Chukwu and Eteng, 2014; Chukwu, 2015) and many parts of the world (Onwueme, 1999, Mishra *et al*., 2008; Mannar and Taylor, 2011; Alcantara *et al*., 2013; Mandal *et al*., 2015). Taro leaves, petioles and flowers are good sources of essential vitamins and minerals and are consumed as vegetables in many cultures in addition to various ornamental, ethno-botanic and traditional uses (Dastidar, 2009; Anon, 2011). Researchers have confirmed other potentials of taro (Ubalua *et al*., 2016) including its uses as carbohydrate adjunct in energy food drinks (Eneh, 2013), agro- industrial raw material for pharmaceuticals (Ferguson *et al*., 1992; Mweta *et al*., 2008; Kundu *et al*., 2012), confectionery (Ukpabi *et al*., 2013) and livestock industries (Anigbogu,1995).

In Nigeria, taro is grown extensively in the humid south particularly, in Enugu, Anambra, Imo and Ebonyi States for local consumption providing alternative source of carbohydrate to augment yam and cassava (Chiejina and Ugwuja, 2013). Reasonable income is also generated from the sales of surplus corms from these productions thereby playing significant role in poverty alleviation. Hong *et al.* (2021) stated that taro leaf blight, caused by a severely destructive Oomycete fungus *Phytophthora colocasiae,* is responsible for threatening yield loss worldwide. The pathogen has the ability to germinate and spread rapidly to other plants during favourable conditions resulting in acute decline and even death, causing 100% crop loss. Symptoms of TLB are primarily seen on the leaf blade as small, dark brown specks which are water-soaked at the lower leaf surface. The lesions soon turn necrotic, assuming round to irregular shapes (Ugwuja and Chiejina, 2011) and rapidly becoming enlarged to 2.5-5.0 cm within few days. The disease also manifest concentric colour patterns on the lesions with orange or reddish-brown exudates and sometime yellowing of the leaf area around the lesion. Severe infection of the petiole causes it to break off and the lamina hangs like a flag. As the disease progresses, adjacent lesions coalesce to cover extensive leaf area and quickly destroys it within 7-14 days causing yield losses of up to 50% (Brunt *et al.* 2001; Misra *et al.,* 2008;) in severe cases and more than 70% in extreme severe cases (Nelson *et al.,* 2011). It should be noted that *P. colocasiae* is the most destructive pathogen of taro and a major constraint to its production all over the countries where taro is grown (Mishra *et al.,* 2008). Similar situations have occurred in Cameroon (Fontem and Mbong, 2011), Ghana, Mauritius (Jugurnauth *et al*., 2001) India (Misra *et al*., 2008) Indonesia and Pacific countries (Nelson *et al.,* 2011) among others resulting to serious crop losses ranging from 50 - 70% and above.

Nigeria is the highest producer of taro globally with about 2.86 million tonnes and share of world total production in 2019 (Otekunrin, 2021). According to FAOSTAT (2021), global taro production stood at 9.76 million tonnes in 2000 and reached 10.54 million tonnes in 2019 with Nigeria, Cameroon, China (mainland) and Ghana ranked 1st, 2nd, 3rd, and 4th respectively. Out of a total of 9.2 million tons produced annually throughout the world in 2008, Nigeria produced 4 million tons but her produce drastically declined from 5,387,000 ton in 2008 to 2,957, 000 tons in 2010 and 3,450, 000 in 2013 (FAO STAT,2015) due to the emergence of TLB in Nigeria. Efforts were made at various quarters to stamp-out this disease or ameliorate its impact. The occurrence of a disease epidemic is the resultant complex interaction between pathogen, host and environment (Mehrotra and Aggarwal, 2003; Agrios, 2005; Damirri, 2011). Thus, in the presence of a virulent pathogen, disease may or may not occur depending on the susceptibility of the host and the suitability of the environment. Each of these components is subject to a considerable variation and as one component changes it can affect disease severity. Nsukka zone is one of the major taro producing areas in Nigeria located north of Enugu State. This zone has exhibited differential response to the TLB scourge with respect to disease incidence among taro varieties and locations since the inception of the disease (Chiejina and Ugwuja, 2013). Scientific information on the severity of taro blight and susceptibility of the two commonly grown varieties to the pathogen across locations in this zone is scarce. Knowledge of the locational and varietal influence on TLB severity is paramount to educating farmers in this zone on the choice of location and the variety to grow in order to reduce losses due to TLB. Therefore this research was undertaken to determine the effects of location and variety on taro leaf blight severity and also to separate the two varieties on the basis of their susceptibility to *P. colocasiae* .

MATERIALS AND METHODS

Field survey

Survey was carried out in three locations within Nsukka Zone: Ede-Oballa, Nsukka-Urban and Obukpa on two local varieties of taro referred to as “Nkashi” (*Colocasia esculenta* var. *esculenta*) and “Ugwuta” (*Colocasia esculenta* var. *antiquorum*). Assessment began in July with the onset of leaf blight and was completed within two weeks. Average rainfall, temperature and humidity obtained during the period from the meteorological section of the department of crop science, University of Nigeria, Nsukka were 13mm, 27.71°C and 75.77% respectively. These variables are the same for all the three locations. In each location, five sites were visited and in each site three taro farms were sampled each for the two varieties. A quadrant measuring 4m x 4m was cast at three different positions and in each, five randomly selected plants were assessed for disease severity and a mean obtained. The experiment was laid out in 2 x 3 x 5 factorial in completely randomized design having factor A= 2Varietes (A1 and A2), B = 3Locations (Ede-Oballa, Nsukka-Urban and Obukpa) and C = 5 Sites per location.

Assessment of disease severity

Disease severity is defined as the percentage plant leaf surface affected by leaf blight (LB), lesions or lesions plus lesion-related chlorosis (Brooks, 2007). New partially furled leaves and old leaves touching the ground were not evaluated. Disease severity was estimated directly for each leaf of a data plant and percent estimates of disease severity converted by angular transformation before statistical analysis (Little and Hills, 1978). The following data were collected: Total number of leaves per plant, number of diseased leaves and the estimated area of leaf covered by the disease including chlorotic area according to Brooks (2007). A modified scale of seven-point (0, 5, 10, 25, 50, 75 and 100) adopted from Brooks (2007) for disease severity assessment was also used.

0 = no disease
5 = less than 1/10 leaf area is diseased
10 = 1/10 leaf area is diseased
25 = ¼ leaf area is diseased
50 = ½ leaf area is diseased
75 = ¾ leaf area is diseased
100= Whole leaf area is diseased

The formula below was used to calculate disease severity:

DS = å %TLB / Lvs

Where,
DS = Disease severity
å = Angular transformation
%TLB = Estimated percentage taro leaf blight per leaf
Lvs = Number of leaves per plant.

Susceptibility of the taro varieties to *P. colocasiae*

Trial was conducted in the screen house with potted taro plants to determine the susceptibility of the two varieties to *P. colocasiae*. Healthy seedlings of each variety were planted one per polyethene bag containing 4kg sterile natural soil, which was previously enriched with farmyard manure. Three plants from each variety were used for this experiment and three replicates were maintained. The plants were watered twice daily. At eight weeks after planting they were inoculated with *P. colocasiae* previously isolated, maintained in agar slants and recultured at the Plant Pathology Laboratory of Plant Science and Biotechnology, University of Nigeria Nsukka. Three leaves of each plant were washed and inoculated with a 2mm agar disc of a seven-day-old culture of *P. colocasiae*. The susceptibility of these varieties to the pathogen was determined by measuring the diameter of diseased spot (lesion) produced on inoculated leaf of each variety from the 3^{trd} day after inoculation to the 8^{th} day. Measurement was taken along two equatorial axes of the lesion on each leaf and their averages recorded to the nearest centimetre (cm).

Data analysis

A multi-locational Analysis of Variance (ANOVA) was done for disease severity. Means separations, was done with Fischer’s Least Significant Difference (FLSD) at P= 0.05. The data obtained from susceptibility trial of the two varieties was subjected to T-Test analysis. All zero data were transformed before statistical analysis to obtain percent values (Little and Hills 1978). The data was analyzed with the GENSTAT package.

RESULTS

The results of the survey conducted in the three locations: Obukpa, Nsukka-Urban and Edeoballa on *Colocasia esculenta* var. *esculenta* and *Colocasia esculenta* var. *antiquorum* revealed that TLB severity varied in the two varieties across the three locations and different sites with remarkably higher percentage severity in the variety *antiquorum*.

The main effects of location on percentage Severity of TLB

Disease severity varied across the various locations investigated irrespective of taro variety (Figure 1). Nsukka-Urban recorded the highest percentage severity of 41.48%, followed by Ede-Oballa, which had 37.80% and Obukpa the lowest with 33.47%. Analysis of variance LSD= 3.50 (0.05) indicates a highly significant difference between Nsukka-Urban and Ede-Oballa as well as Nsukka-Urban and Obukpa. However, difference in severity between Ede-Oballa and Obukpa was not significant.

The main effect of variety on percentage severity of TLB

The result of the main effect of variety on disease severity is shown in Figure 2. Var. *antiquorum* recorded significant higher severity 45.30%, LSD= 2.86 (0.05) than var. *esculenta*, which had 33.20%.

The interactive effects of variety and location on percentage severity of TLB

The interactive effects of variety and location on disease severity as presented in Table 1 revealed that TLB severity was significant LSD=4.96 (0.05) and more severe in var. *antiquorum* than in var. *esculenta* in all the locations. The overall highest severity was recorded at Nsukka and the least was recorded at Obukpa.

The interactive effects of variety and site on percentage severity of TLB

The interactive effects of variety and site on TLB severity are shown in Table 2 below. Disease severity varied from one site to another in the two varieties and was significantly ($p < 0.05$) higher in var. *antiquorum* than on var. *esculenta* in all the sites investigated. Var. *antiquorum* recorded 47.61%, 43.40%, 41.51%, 41.36% and 52.61% against 31.01%, 35.47%, 30.93%, 29.89%, and 38.70% recorded by var. *esculenta* in sites 1-5 (S1-S5) respectively. Across the sites, severity was almost the same within a particular crop type. Severity in S1 for *esculenta* did not differ significantly with severity in S2-S4 respectively. However, S5 had the highest severity, which is weakly significant. In the variety *antiquorum*, disease severity did not vary significantly across the sites with the exception of S5, which had highest severity.

The interactive effects of location and site on percentage severity of TLB

The interactive effects of location and site on disease severity are shown in Table 3. Percentage severity varied across the various sites in the three locations. Site 5 (S5) at Obukpa had the highest severity 46.59%, followed by S5 and S1 at Nsukka, which had 46.10% and 45.97% respectively. S1 at Ede-oballa recorded the least severity 28.85%. Statistical analysis, LSD=7.84 ($p < 0.05$) indicates that at Ede-oballa, disease severity in sites S2-S4 did not differ significantly from each other and with that of S1-S5 at Nsukka which were statistically the same. At Obukpa severity in the sites, appear to be statistically the same except S4.

The interactive effects of variety, location and site on percentage severity of TLB

The interactive effects of variety, location and site on disease severity are shown in Table 4. Var. *antiquorum* recorded higher severity than *esculenta* in all the sites and locations. Percentage severity in *antiquorum* and *esculenta* ranged from 35.66% - 55.69% and 21.82% - 42.02% respectively. The highest severity was recorded at Nsukka in *antiquorum* while the lowest was recorded at Obukpa in *esculenta*. Within Nsukka, severity did not vary significantly in var. *esculenta* across the sites 1-5 (S1-S5). Within Obukpa, severity did not also vary significantly in *esculenta* across S1-S5 but within Ede-oballa, S2-S5 varied significantly with S1and not with each other. Within Ede-oballa, severity in var. *antiquorum* did not vary significantly across S1-S4 and S2- S4 at Obukpa but varied significantly with S1 and S5.

Susceptibility of the taro varieties to *P. colocasiae*

The susceptibility of *Colocasia esculenta* var. *esculenta* and *Colocasia esculenta* var. *antiquorum* to *P*. *colocasiae* 8 dai (days after inoculation) differed significantly (P< 0.05). Var. *antiquorum* had greater rot portion (lesion diameter) ranging from 0.65±0.07 cm - 3.70±0.14 cm with an average lesion diameter of 2.4±0.16cm compared to var. *esculenta* which had 0.41±0.14cm - 3.12±0.19 cm and average lesion diameter of 1.80±0.16 (Figure 3) Comparisons between the two means using t-test indicate that var. *antiquorum* was significantly more susceptible to the pathogen than var. *esculenta*. The diameter of lesion increased as the time (days after inoculation) increased and in the var. *antiquorum*, lesions grew more rapidly.

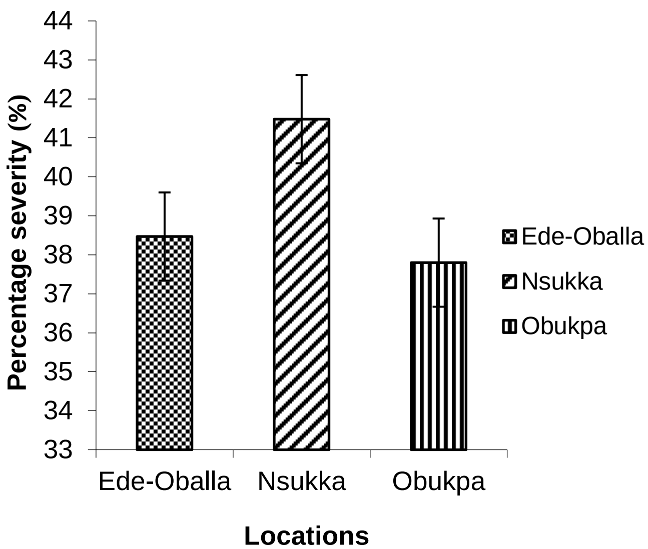

Figure 1: The main effect of location on percentage severity of taro leaf blight

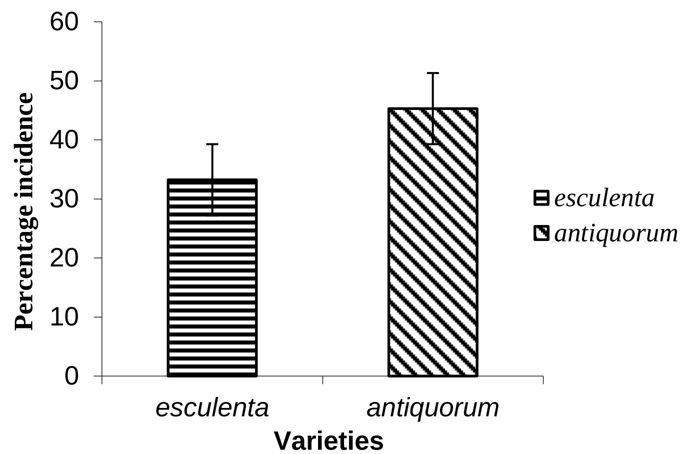

Figure 2: The main effect of variety on the severity of Taro leaf blight

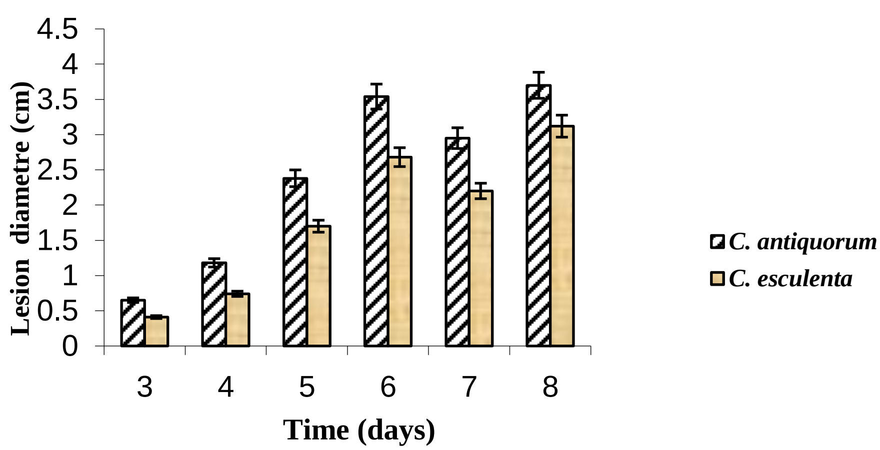

Figure 3: Susceptibility of *C*. *antiquorum* and *C*. *esculenta* to *P*. *colocasiae 8* days after inoculation

(Mean lesion diameter 8 days after inoculation: *C.antiquorum)* =2.4±0.16; *C.esculenta* =1.8±0.1; P =0.038).

Table 1: The interactive effects of variety and location on percentage severity of taro leaf blight.

	Locations		
Varieties	Ede-Oballa	Nsukka	Obukpa
esculenta	34.85	36.55	28.19
antiquorum	42.08	46.40	47.42

LSD=4.96 (Interaction).

Table 2: The interactive effects of variety and site on percentage severity of taro leaf blight.

	Sites				
Varieties	S1	S2	S3	S4	S5
Esculenta	31.01	35.47	30.93	29.89	38.70
Antiquorum	47.61	43.40	41.51	41.36	52.61

LSD=6.40 (Interaction)

Table 3: The interactive effects of location and site on percentage severity of taro leaf blight

	Sites				
Locations	S1	S2	S3	S4	S5
Ede-oballa	28.85	40.64	38.64	39.93	44.27
Nsukka	45.97	42.15	35.59	37.57	46.10
Obukpa	43.11	35.52	34.43	29.37	46.59

LSD=7.84 (Interaction)

DISCUSSION

The results have established variations in TLB severity in *C*. *esculenta* var. *antiquorum* and *C. esculenta* var. *esculenta* across the three major taro growing locations in Nsukka Zone. The results also revealed differences in susceptibility of the varieties to the leaf blight pathogen *P. colocasiae*. This agrees with the findings of Forkunang *et al.* (2016) who demonstrated differences in TLB disease severity among 10 improved and 4 local cultivars of taro. Similarly, Omeje *et al.* (2016) established cultivar differences with respect to TLB severity while investigating the effect of cropping season on the control of TLB of cocoyam in Nsukka, South Eastern Nigeria. The significant differences in TLB severity and susceptibility amongst the varieties could be attributed to genetic constitution which tends to vary among varieties of taro as supported by the work of Miyasaka *et al*. (2012) and Mandal *et al.* (2013).

In the present study, the variety *esculenta* "nachi" was more resistant to the TLB, suggesting that it would produce more yields across these locations under TLB condition than its counterpart *antiquorum*, "ugwuta". This result corroborated the findings of Omeje *et al.* (2016) who obtained lower yield from *colocasia antiquorum* "ugwuta" under taro leaf blight condition.

Table 4: The interactive effects of variety, location and site on the percentage severity of taro leaf blight.

	var. *esculenta*			var. *antiquorum*		
Site	Ede	Nsk	Obu	Ede	Nsk	Obu
1	22.03	40.47	30.53	35.66	51.48	55.69
2	42.02	37.03	27.35	39.26	47.27	43.68
3	37.16	32.28	23.36	40.13	38.90	45.50
4	36.34	31.49	21.82	43.51	43.65	36.93
5	36.72	41.50	37.89	51.83	50.69	55.30

LSD=11.0 (Interaction).

Table 5: Analysis of Variance (ANOVA)

Analysis of Variance

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Variety	1	9877.8	9877.8	69.21	< .001
Location	2	690	345	2.42	0.091
Village	4	3421.8	855.5	5.99	< .001
vty.location	2	1792.5	896.3	6.28	0.002
vty.village	4	588	147	1.03	0.392
loc. Village	8	4103.3	512.9	3.59	< 0.001
vty. Loc. Village	8	811.6	101.4	0.71	0.682
Residual	240	34253.4	142.7		
Total.	269	269	55538.4		

The higher resistance portrayed by var. *esculenta* suggests that it may contain higher levels of disease resistant compounds like phenols and polygalacturonase inhibitors (Ugwuja and Chiejina, 2011; Omane *et al*., 2020). In addition, the severity of TLB is dependent on *Phytophthora* population (the amount of inoculum) in the field at the time of planting (Brooks, 2007) and host plants carrying partial (horizontal) resistance will probably become infected but the rate at which the disease develops depends on the environmental conditions (Agrios, 2005). The susceptibility of the varieties to the pathogen as expressed by the rate of growth of lesions on leaves days after inoculation clearly indicates that var. *antiquorum* was more susceptible as lesions grew faster on it than that of var. *esculenta*. This is indications that complete destruction of leaves or whole plant would be swifter in the variety *antiquorum.*

The main effect of location on disease severity has shown that TLB severity varied from one location to another irrespective of crop type. The observed significant variations in disease severity which prevailed across the locations suggest that a location where taro is grown has an important role to play in the disease probably due to differences in soil type, soil fertility, soil pH, topography, vegetation and microclimatic conditions which were peculiar to different locations. This was consistent with a previous study by Adinde *et al*. (2016) who observed significant differences in TLB incidence and severity across different villages in Iwollo and attributed the differences to varied agronomic practices across the villages. Similarly, Onyeka (2014) reported variable (65% - 90%) TLB incidences across 8 states representing taro growing agro-ecologies in Nigeria. This is in line with the recognition by earlier studies that environment is one of the major factors that influence disease development (Mehrotra and

Aggarwal, 2003; Agrios, 2005), having the capacity to induce an epidemic or retard its development. CABI (2020) also noted that *P. colocasiae* occurs under conditions of high temperature and humidity, in wet areas and densely planted fields. Although disease severity in the sites irrespective of locations varied, results have shown that the effect of site on disease severity was not remarkably significant. The noticeable differences in disease severity among a few sites within a location could be attributed to different cultural practices including time of planting, types and methods of manuring, weeding and other agronomic practices observed by each individual farmer before, during and after planting. It was reported that time of planting, manuring, spacing and intercropping affect incidence and severity of *Phytophthora* blight (Misra *et al.,* 2007; Tarla *et al*., 2014). Personal observation has shown that some farmers planted their crops long before the outbreak of the infection while others planted just before the infection and others soon after the outbreak. Some researchers opined that in some plant-pathogen interaction such as *Pythium* damping off, downy mildews, *Phytophthora* and viral infections the hosts which have attained reasonable maturity and vigor before the outbreak of an infection, would show more resistance to the infection than those in their juvenile stages - a phenomenon known as ontogenic resistance (Mehrotra and Aggarwal, 2003; Agrios, 2005). Consequently, earlier planted taro crops, before the incidence of TLB are likely to have lesser disease than those planted at the onset of disease. Preliminary findings also indicated that adequate fertilizer treatment may help to cushion the effect of the leaf blight on taro plants (Tilialo *et al*., 1996). Pearson *et al* (1999) observed that wide spacing of plants and avoiding planting near an infected plot reduce disease intensity.

The interactive effect of variety and location on disease severity was shown to be significant and more severe in the var. *antiquorum* in all the locations. Although var. *antiquorum* has been implicated to be more vulnerable to TLB, the similar severity obtained in different locations is an indication that it would tolerate wider ranges of environmental conditions particularly, different soil types, other edaphic factors and micro climatic factors and given the absence of TLB and the availability of adequate weather conditions can do well across these locations. Conversely, there is probably more genetic diversity in the var. *esculenta* which implies that it would have greater chances of resisting a new race of the pathogen that can attack these varieties if there was an epidemic (Agrios, 2005).

Differences in disease severity were observed within crops of same variety in the same location. These differences might be due to the presence of different *P. colocasiae* strains which can manifest different level of virulence or pathogenicity. This was supported by the findings of Misra *et al* (2011), Nath *et al*. (2013) and Otieno (2020). Misra *et al*. (2011) noted a high variation in *Phytophthora* leaf bight severity and yield losses among fields planted with the same taro cultivars and under similar condition. Similarly, the other authors demonstrated high variability in *Phytophthora colocasiae* associated with leaf blight of taro in different experiments. In the same vein, Adomako *et al*. (2017) reported that significant differences were observed among isolates of *P. colocasiae* based on the size of lesion each isolate induced on infected taro leaf. Okereke (2020) also reported that *P. colocasiae* could lead to a devastating yield loss thereby jeopardizing the livelihoods and food security of small farmers and rural communities dependent on the crop. Variety *esculenta* exhibited the lowest TLB severity across the locations and was relatively more resistant to the pathogens. This suggests that var. *esculenta* will perform better under blight condition especially at Obukpa area. Obukpa generally had the lowest disease severity in the two varieties compared to Edeoballa and Nsukka which is an indication that it could be the best location for the production of taro with minimal loses to TLB in Nsukka Zone.

In conclusion, the variability of TLB severity among *Colocasia esculenta* var *antiquorum* and *Colocasia esculenta* var. *esculenta* in the three locations: Edeoballa, Nsukka Urban and Obukpa within Nsukka agro-ecological zone signifies that locations where taro crops were grown play important role in TLB severity. Based on the results of the field survey and screen house analysis, it is evident that the variety *esculenta* demonstrated better level of resistance to the TLB pathogen and would produce better yield under taro leaf blight conditions than its counterpart. It is therefore hoped that taro farmers in this zone would adopt early planting, good cultural practices, adequate manuring in addition to planting more of the variety *esculenta* in order to minimize losses to *Phytophthora* leaf blight disease.

Conflict of interest

The authors declare that they have no conflict of interest.

REFERENCES

Aboubakar, N.Y. N., Scher, J. and Mbofung, C. M. (2008). Physicochemical, thermal properties and microstructure of six varieties of taro (*Colocasia esculenta L.* Schott) flours and starch. *Journal of Food Engineering*, **86**: 294–305.

Adinde, J. O. Anieke U. J. Nwankwo, O. G., Agu, C. J. Aniakor , A. C. Nwagboso, A. A. and Eze, C. O.(2016). Incidence and severity of taro leaf blight in Iwollo, South - Eastern Nigeria. *International Journal of Current Research in Bioscience and Plant Biology*, **13(10)**:163-168.

Adomako, J., Kwoseh, C. and Moses, E. (2017). Metalaxyl sensitivity and aggressiveness of *Phytophthora colocasiae* isolates associated with taro leaf blight disease. *Journal of Plant Pathology*, **99 (1)**:205-210.

Agrios, G. N. (2005). *Plant Pathology* (5th edition). Academic Press. 922pp.

Alcantara, R. M., Hurtada, W.A. and Dizon, E. I. (2013). The nutritional value and phytochemical components of aro [*Colocasia esculenta* (L.) Schott] powder and its selected processed foods. *Journal of Nutrition and Food Sciences,* **3**: 207.

Amusa,T.A., Enete, A. A. and Okon, U.E. (2011).Socioeconomic determinants of cocoyam production among small holder farmers in Ekiti State, Nigeria. *International Journal of Agricultural Economics & Rural Development,* **4** (2):97-109.

Anigbogu, N. M. (1995). Taro as a substitute for corn in broiler rations*. IITA Tropical Root and Tuber Bulletin*, **8**(2**)**: 89.

Anon (2011). Botany–Taro (*Colocasia* e*sculenta*). *http//www.123helpme.com/preview.asp ? id* accessed 21st June, 2013.

Brooks, F. E. (2007). Methods of measuring taro leaf blight severity and its effect on yield. *Technical Report* No. 35: 59-71. The American Samoa Community College Land Grant Program. College of Tropical Agriculture & Human Resources, University of Hawaii, Manoa, USA.

Brunt, J., Hunter, D. and Delp, C. (2001). *A bibliography of taro leaf blight*. Secretariat of the Pacific Community (SPC)/AusAID taro genetic resources: conservation and utilization. Noumea, New Caledonia, 93 pp.

CABI (2020). *Phytophthora colocasiae* (taro leaf blight). www.cabi.org. Assessed 18th August, 2021.

Chiejina, N. V. and Ugwuja, F. N. (2013). Incidence of *Phytophthora* leaf-blight disease of cocoyam in Nsukka area of South-Eastern Nigeria. *Journal of Botanical Research,* **4**(1):21-24.

Chukwu, G. O. and Eteng, E. U. (2014). Enhancing soil health and control of cocoyam rot through integrated plant nutrition. *Basic Research Journal of Soil and Environmental Science*, **2**(4):40-45.

Chukwu, G. O. (2015). Land use for cocoyam in Nigeria: implications for cocoyam re-birth. *Journal of Hill Agriculture,* **6**(1):1-7.

Damiri, N. (2011). Climate change, environment and plant diseases. In: *Proceedings of the International Seminar, Sriwijaya University Cooperation with CRISU and CUPT*, pp200-205. ISBN 978- 979-98938-5-7.

Dastidar, S.G. (2009). *Colocasia esculenta*: an account of its ethnobotany and potentials. M.Sc. Thesis. The University of Texas at Austin.

Eneh, C. O. (2013). Towards food security and improved nutrition in Nigeria: Taro (*Colocasia antiquorum*) grit as carbohydrate supplement in energy food drink. *African Journal of Food Science,* **7**(10):355-360.

FAOSTAT. Food and Agriculture Organisation of the United Nations Statistical Database (2021). Statistical Division; FAO: Rome, Italy; Available online: http://www.fao.org/statistics/en/

FAO (2009). FAO Economic and Social Department - The statistics division. Major food and agricultural commodities and their producers. http://faostat.fao.org/site/339/default.aspx. Assessed on 15 May 2016

FAOSTAT (2015). Facts fish taro production quantity for Nigeria. Food and Agricultural Organization of the United Nation. *http://www.factfish.com/print.*

Ferguson, L. R., Roberton, A. M. and Mckenzie, R. J., Watson, M. E. and Harris, P. J. (1992). Adsorption of a hydrophobic mutagen to dietary fibre from taro (*Colocasia esculenta*) an important food plant of the south pacific. *Nutrition and Cancer*, **17**: 85-95.

Fontem, D.A. and Mbong, G.A. (2011). *A novel epidemic of taro (Colocasia esculentum) blight caused by Phytophthora colocasiae* hits Cameroon. In: *Life Science Animal Production*. Third life science conference. Cameroon Forum for Biological Science.

Fokunang, C.N, Mbong, G.A., Manju, E., Tembe, E. and Rachid, H. (2016). Screen house and field resistance of taro cultivars to aro leaf blight disease (*Phytophthora colocasiae*). *British Biotechnology Journal*, **15** (1):1-15.

Hong, Z., Talib, K. M., Mujtaba, K. G., Yahya, Dabin, H., Yahya, F., Congying, Z and Fukai, W. (2021**).**Antifungal potential of cinnamon essential oils against *Phytophthora colocasiae* causing taro leaf blight. *Chemical and Biological Technologies in Agriculture*, **8:**39**.**

Jugurnauth, S., Soomary, S. and Hanoomanjee, P. (2001). *Production of major Colocasia spp. in Mauritius: Current status, constraint and opportunities*. Food and Agricultural Research Council Reduit, Mauritius. 7 pp.

Kundu, N., Campell, P., Hampton, B., Lin, C., Ma, X., Ambulos, N., Zhao, X.F., Goloubewa, O., Holt, D. and Fulton, A.M. (2012). Antimetastic activity of compound isolated from *Colocasia esculenta* (taro). *Anti-Cancer Drugs*, **2**: 200-211.

Little, T. M. and Hills, F. J. (1978). *Agricultural Experimentation: Design and Analysis*. John Wiley and Sons, New York. 245pp.

Mandal, R., Mandal, N., Mitra, S., and Jarafdar, J. (2015). Development of DUS statandard for taro (*Colocasia esculenta* var. antiquorum (L.) Schott) using digital morphometrics. *Applied Biological Research*, **17(1**): 70-76.

Mandal, R., Mukherjee, A. and Mandal, N. (2013). Assessment of genetic diversity in taro using morphometrics. *Current Agricultural Research Journal*, **1**: 97-85.

Manner, H. I. and Taylor, M. (2011) (revised). *Farm and forestry production and marketing profile for taro* (*Colocasia esculenta*). Permanent Agriculture Resources (PAR), Holualoa, Hawaii. 34pp.

Mehrotra, R.S. and Aggarwal, A. (2003). *Plant Pathology*. (2ndedition). Tata McGraw-Hill. New Delhi, New York. 846pp.

Mishra, A. K., Sharma, K. and Misra, R.S. (2008). Effect of benzyl amino purine on the pathogen growth and disease development of taro leaf blight caused by *Phytophthora colocasiae*. *Journal of Plant Pathology,* **90**:191-196.

Misra, R.S., Maheshwari, S.K., Sriram, S and Sahu, A.K (2007a). Effect of intercropping on the incidence and severity of *Phytophthora* leaf blight disease in taro (*Colocasia esculenta* (L.) Schott). *Journal of Root Crops,* **33**: 67-69

Misra, R.S., Mishra, A.K., Sharma, K., Jeeva, M.L. and Hegde, V. (2011). Characterization of *Phytophthora colocasiae* isolates associated with leaf blight of taro in India. *Archives of Phytopathology and Plant Protection*, **44** (6): 581-591.

Misra, R.S., Sharma, K. and Mishra, A. K. (2008). *Phytophthora* leaf blight of taro (*Colocasia esculenta*)- a review. *The Asian and Australian Journal of Plant Science and Biotechnology* **2**(2):55-63.

Mweta, D. E., Labuschagne, M. K., Koen. E., Benesi, I. R and Saka J. D. (2008). Some properties of starches from cocoyam (*Colocasia esculenta*) and *Manihot esculenta* Crantz) grown in Malawi. *African Journal of Food Science,* **2**: 102-111.

Miyasaka, S. C., McCulloch, C.O.and Nelson, S. C. (2012). Taro germplasm evaluated for resistance to taro leaf blight. *Hort Technology*, **22**: 838-849.

Nath, V. S, Senthil, M., Hedge, V. M., Jeeva, M. L., Misra, R. S., Veena, S. S. and Raj, M. (2013). Molecular evidence supports hyper variability in *Phytophthora colocasiae* associated with leaf blight of taro. *European Journal of Plant Pathology*, **136**: 483-494.

Nelson S, Brooks F, Teves G. (2011). Taro leaf blight in Hawaii. Plant Diseases Bulletin No. PD -71; University of Hawaii: Manoa, HI, USA. New Caledonia.

Okereke, N.R. (2020). Taro leaf blight: threat to taro (*Colocasiae esculenta* L. Schott) production. *Nigeria Agricultural Journal,* 51(2): 281-286.

Omane, E.K., Asare, O.E., Cornelius, A.Y., Akrofi, E.K., Asare, B. and Adongo, A. (2020). Improvement in the management of leaf blight disease of taro (*Colocasiae esculenta*) with copper and metalaxyl fungicides. *Journal of Experimental Agriculture International,* **10**:127-136

Omeje, T. E., Ugwoke, K. I., Adinde, J. O., Ogwulumba, S. I. and Unigwe, L. O. (2016). Effect of cropping season on the control of taro leaf blight (*Phytophthora colocasiae*) of cocoyam (*Colocasia esculenta* L. Schott.) in south eastern Nigeria. *International Journal of Advanced Biological Research,* **6**(1): 30-39.

Onwueme, I. C. (1999). *Taro cultivation in Asia and the Pacific*. Food and Agriculture Organization of the United Nations, Regional office for Asia and the Pacific, RAP Publication No.16. Bangkok, Thailand. 50pp.

Onyeka, J. (2014). *Status of Cocoyam (Colocasia esculenta and Xanthosoma spp) in West and Central Africa: Production, Household Importance and the Threat from Leaf Blight*, Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). Available online at: www.rtb.cgiar.org. Assessed 14 July 2016.

Otekunrin, O.A., Sawicka, B., Adeyonu, A.G., Otekunrin, O.A.and Racho, N. L. (2021). Cocoyam [*Colocasia esculenta* (L.) Schott]: Exploring the Production, Health and Trade Potentials in Sub-Saharan Africa. Sustainability, **13**:44-83.

Otieno, C. A. (2020). Taro leaf blight (*Phytophthora colocasiae*) disease pathogenicity on selected taro (*Colocasia esculenta*) in Maseno, Kenya. *Open Access Library Journal*, 7: e6393. *https://doi.org/10.4236/oalib.1106393*.

Pearson, Pearson, M. N., Jackson, G.V.H., Saelea, J. and Morar, S. G. (1999). Evidence for two rhabdoviruses in taro (*Colocasia esculenta*) in the Pacific region. *Australasian Plant Pathology,* 28: 248-253.

Tarla, D. N., Fon, D. E., Takumbo, E. N. and Fontem D.A. (2014). Economic evaluation of fungicides application on taro (*Colocasia esculenta)* leaf blight. *Journal of Experimental Biology and Agricultural Science*, ISSN nNo.2320-8694:286-296.

Tilialo, R., Greenough, D. and Trujillo, E. E. (1996). The relationship between balanced nutrition and disease susceptibility in Polynesian taro. In: *Mineral nutrient disorders of root crops in the Pacific*. Proceedings of a workshop, Nuku'alofa, Kingdom of Tango, 17-20 April, 1995, ACLAR, **65**:105-109.

Ubalua, A. O., Ewa, F. and Okeagu, O. D. (2016). Potentials and challenges of sustainable taro (*Colocasia esculenta*) production in Nigeria. *Journal of Applied Biology and Biotechnology,* **4**(1): 54-59.

Ugwuja, F. N. and Chiejina, N.V. (2011). Preliminary investigation of the causes of leaf rots of cocoyam in Nsukka zone of Nigeria. *Nigerian Journal of Plant Protection,* **25**:203-213.

Ukpabi, U. J., Chijioke, U. and Mbanaso, E. N. A. (2013). Feasibility of producing acceptable carotene and energy rich taro crisps with deep palm-oil frying in Nigeria. *Pakistan Journal of Nutrition*, **12**(9): 811-814.