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FIELD MANAGEMENT OF *PHYTOPHTHORA* BLIGHT DISEASE OF COCOYAM (*Colocasia esculenta* L.) WITH SPRAY REGIMES OF SELECTED FUNGICIDES IN NSUKKA, SOUTH EASTERN NIGERIA

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ABSTRACT
Cocoyam (Colocasia esculenta L). is an important edible tuber crop, but taro leaf blight caused by Phytophthora colocasiae has been the greatest constraint to cocoyam production in Nigeria since 2009. Field trials were conducted to determine the effect of fungicides and the spray regimes on leaf growth, disease incidence, disease severity and tuber yield of cocoyam. The trials were carried out at the Department of Crop Science Research Farm, University of Nigeria, Nsukka for two planting seasons. Treatments with three fungicides (Ridomil Gold Plus, Ridomil+ChampDp 50%:50% mixture and control) and five spray regimes (No spray, weekly spray, 2nd weekly spray, 3rd weekly spray and 4th weekly spray regimes) were laid out in a 3 x 5 factorial in randomized complete block design (RCBD) with three replications. Results showed that fungicide treatments had significant (P < 0.05) variation on number of leaves/stand, disease incidence, disease severity and tuber yields/hectare in both cropping seasons. Thus, there was no significant (P > 0.05) differences between Ridomil and Ridomil+Champ (50%:50%) mixture) on all measured parameters in both cropping seasons. The fungicides and the spray regimes significantly reduced taro leaf blight, improved growth and yields . Ridomil treated cocoyam plots at weekly spray regimes performed best compared to other fungicides and the spray regime treatment options..

Key words: *Colocasia esculenta*, *Phytophthora colocasiae*, Fungicides, Spray regimes, and Nsukka.

INTRODUCTION

Cocoyam (*Colocasia esculenta* L Shott) belongs to a member of ariod family- *Aracae*. It is an important edible stem tuber cultivated in the humid forest regions of Nigeria (Ojiako *et al,* 2007). Cocoyam is the most important tuber crop after yam and cassava in Nigeria (Echebiri, 2004) with various forms of utilization in human food, animal feed and industrial raw materials. Cocoyam leaves, petioles and flowers are rich in minerals and are used as vegetables in various parts of the world.

Despite, the socio-cultural/economic importance of cocoyam in achieving national food security, income generation among women and youths and the nutritional enhancement, there were severe yield losses of cocoyam in Nigeria in the last few years due to cocoyam disease . Cocoyam is attacked by many diseases, but the most destructive cocoyam disease in Nigeria was caused by Oomycetous fungus - *Phytophthora colocasiae* Raciborski. Taro leaf bight was first described in Java (Indonesia) by Raciborski (1900). The first observation of taro leaf blight from Philippines was in 1916 (Gomez, (1925), Hawaii in 1941 (Paris, 1941), Nigeria in 2009 (National Root Crop Research Institute, NRCRI, 2012), and Cameroon in 2010 (Mbong *et al*., 2013). Over the years, the taro leaf blight has posed great challenges to taro farmers and researchers. The production of taro

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with regular routine spray of copper oxychloride at the rate of 2.5 kg active ingredient (a.i) /38 litres of water per hectare provided superior control of taro leaf blight and higher yield of taro compared to Mancozeb and Captafol protectants in Solomon Islands (Jackson and Gollifer, 1975). However, there is scanty information on the use of fungicide spray regimes on control of taro leaf blight of cocoyam cultivars in Nigeria.

Therefore, the primary aim of this study was to determine the efficacy of fungicides and the spray regimes on the control of taro leaf blight of cocoyam in Nsukka, South- East Nigeria.

MATERIALS AND METHODS

Experimental site: Field experiments were conducted in the early and late cropping seasons of 2013 at the Department of Crop Science Research Farm, University of Nigeria, Nsukka. Nsukka is located at the derived Savannah region of South Eastern Nigeria (Latitude 06^o 54N, longitude 07^o 24E and 447.26 meter above sea level). The rainfall distribution pattern is bimodal with peaks in July and September and short-dry season around early August (August break). The mean annual rainfall ranges between 1500 mm -1900 mm with a mean annual temperature of 25 – 29^{o}C and Relative humidity of 69 - 79% (Uguru, 2011). The soil is a well drained sandy clay loam classified as an ultisol (Nwadialor, 1989).

Field design, treatment and treatment allocation

The field experimental design was 3 x 5 factorial experiment in randomized complete block design (RCBD) with three replications. The experiment was done in the early season (April – November) and repeated in late reason (July – December). The factors were three fungicide treatments (Ridomil gold plus (active ingredient (a.i) 6% Metalaxyl and 60% copper), Ridomil + champ (a.i Copper hydroxide) (50%: 50% mixture) and control), and five spray regimes (No spray, weekly spray, 2nd weekly spray, 3rd weekly spray and 4th weekly spray) and Nachi cultivar. There were 15 experimental units. The fungicides were sprayed at the rate of 2.5kg per hectare (ha) mixed with an insecticide (Attack a.i lambdacyhalothrin 2.5EC) at the rate of 800 ml in 100 litres of water to check foliar insect pests like taro aphids (*Myzus persicae*), Mealybugs and taro plant hopper (*Tarophagus proserpina*). All sprays were done during the early morning hours when weather action (wind) was calm usually at the onset of disease symptoms; at 75 and 60 days after planting (DAP) in early and late planting seasons, respectively.

Cultural management practices

The research field was cleared, ploughed, harrowed and made into mounds with hoe. Prior to mound making 15 tonnes per hectare of well cured poultry manure was uniformly broadcast and incorporated into the soil. Cocoyam at average weight of 25-35g/cornel/mound was sown at a depth of 5-8 cm at an intra and inter row spacing of 0.5m x 0. 5 m. The plant population of 100 stands per plot (40,000 stands per hectare) was used. Weeds were manually checked with hoes and hand picking where necessary. A second dose of manure (15 tonnes per hectare) was applied at 7 weeks after planting (WAP), followed by re-mounding for proper taro growth and development. The Cocoyam tubers were harvested at full maturity in November and December for early and late planting seasons, respectively.

Data collection

The agronomic and disease parameters were collected from five randomly selected and tagged stands from the central row. Data were collected on number of leaves/stand, disease incidence (%), disease severity on 5 point scale (0 - 4scale) at 90 ,120 and 150 days after planting (DAP) and yields/hectare (kg/ha). Disease incidence was recorded as a ratio of the number of plants showing disease symptoms over total number of plants multiplied by 100 (%).

Disease severity was estimated on 5 point scale (0 – 4 scale) as severity score range (%) determined by the area of plant leaves blighted (infected) over total area of plant leaves x 100 **(%)** as described by Chaube and Pundhir (2005) as below:

$$Severity\ (\%) = \frac{Area\ of\ Plant\ Leaves\ blighted}{Total\ area\ of\ plant\ leaves} \times \frac{100}{1}$$

Scales	Severity score range (%)		Description
0	< 1	=	No infection
1	1 – 25	=	Low infection
2	26 – 50	=	Moderate infection
3	51 -75	=	High infection
4	>75	=	Very high infection.

Data Analysis: Data collected were subjected to analysis of variance (ANOVA) using GenStat release 10.3 DE software (2011), and Fisher's least Significant difference (F - LSD) was used to compare treatment means where significance was observed at 5% probability level as described by Obi (2002).

RESULTS

The results of weather data shown in Table 1 presented a marked variation of climatic parameters in 2013. Rainfall pattern showed bimodal rainfall with peaks in May and July.

(Table 1). The total amount of rainfall received during the trial period can be seen in Table 1 The mean maximum and minimum temperatures for the year and the relative humidity range are shown in Table 1. Result of number of leaves/stand as seen in Table 2 showed significant (P < 0.05) difference among the fungicides with Ridomil treated plants consistently maintaining the highest values compared to other fungicide options. These values were statistically similar to Ridomil+Champ (50%:50% mixture), but differed significantly from control plots in early season planting (Table 2). The combined effect of fungicides and the spray regimes differed significantly (P < 0.05) on number of leaves/stand during the periods of study except at 150 days after planting (DAP) in early season planting (Table 2) . However, at 150 DAP, Ridomil treated plants at weekly spray had the highest number of leaves/stand during the study period . Next was Ridomil+Champ (50%: 50% mixture) at weekly spray, and the least number of leaves was produced by the control treated plots. At 90 and 120 DAP, Ridomil+Champ (50%: 50% mixture) and Ridomil both at weekly spray regimes had the highest number of leaves/ stand compared to other combined effects. These values were statistically similar to Ridomil and Ridomil+Champ (50%: 50% mixture) both at weekly spray, but significantly differed from the control plots. In late season planting, there were significant (P < 0.05) differences among the fungicides on number of leaves/stand during trial periods (Table 2). At 90 - 120 DAP, Ridomil treated plants had the highest number of leaves/stand during the trial periods, while the least number of leaves/stand were produced by all control treated plots. However, at 150 DAP, control treated plots recorded the highest number of leaves/stand, and the least number of leaves/stand was obtained in Ridomil+Champ (50%:50%mixture) treated plants. The fungicides and the spray regimes combined effect showed significant variation on number of leaves/stand except at 120 DAP during the trial periods as shown in Table 2. However, at 120 DAP, Ridomil treated plots at weekly spray regime produced the highest number of leaves/stand, and the least number of leaves/stand was produced by the interaction of Ridomil + champ (50%:50% mixture) at 4th weekly spray regime. At 90 and 150 DAP, Ridomil plots at 3rd weekly spray; and the control plots recorded the highest number of leaves/stand, and the least number of leaves/stand were obtained by Ridomil at No spray and Ridomil+Champ (50%:50% mixture) at 2nd weekly spray regime interaction effects. The seasonal effect on number of leaves per stand significantly (P < 0.05) varied at the sampling periods with late season producing a higher number of leaves/stand than early season planting at 90 - 120 DAP . At 150 DAP, early season had significantly more number of leaves/stand than the late season planting.

Table 1: Agro-Meteorological data showing total monthly rainfall (mm) Rainy days, maximum and minimum temperature (°C) Relative humidity (%) of the study sites in 2013

Month	Total rainfall (mm)	Rainy days	Mean temperature (°C)		Relative Humidity (%)	
			Maximum	Minimum	10am	4pm
January	21.84	2.00	31.23	20.55	75.00	75.00
February	0.00	0.00	32.86	22.18	75.00	75.00
March	38.10	5.00	32.81	22.58	72.74	62.94
April	183.81	10.00	30.67	22.30	74.00	68.90
May	198.63	11.00	29.52	21.61	74.77	69.87
June	168.60	11.00	28.67	21.17	75.67	72.70
July	283.96	19.00	27.35	20.71	74.90	73.61
August	219.18	12.00	26.61	20.26	76.13	76.16
September	197.60	16.00	27.43	20.50	77.00	77.00
October	167.90	11.00	28.55	20.74	77.00	77.00
November	41.91	2.00	30.37	21.70	77.00	77.00
December	15.75	2.00	29.35	19.39	66.77	66.03
Total	1537.28	101.00	354.42	253.69	895.98	871.66
Mean	1537.28	8.42	29.54	21.14	74.67	72.64

Source: Faculty of Agriculture Meteorological Station, University of Nigeria, Nsukka.

Table 2: Fungicide treatments, spray regimes and seasonal effect on number of leaves per stand of cocoyam (*Colocasia esculenta* L.) at the stipulated Days after planting (DAP) in 2013 early and late planting seasons

		Early season			Late season		
Fungicide Treatments	Spray	90DAP	120DAP	150DAP	90DAP	120DAP	150DAP
Control	No Spray	6.42	7.51	9.89	7.36	10.40	9.07
	1week	6.58	7.49	10.60	6.53	11.04	11.73
	2weeks	6.73	7.36	10.16	7.22	13.09	13.67
	3weeks	7.13	8.42	10.16	7.56	11.78	12.42
	4weeks	6.24	7.22	11.84	6.62	11.40	10.58
	Mean	6.62	7.60	10.53	7.06	11.54	11.49
RD+CHP	No Spray	6.42	7.93	10.98	7.11	9.36	8.96
	1week	11.62	13.67	16.51	13.04	15.31	8.89
	2weeks	9.73	11.20	14.40	11.73	12.82	5.98
	3weeks	7.58	9.51	13.69	10.58	12.09	8.42
	4weeks	8.16	10.60	12.93	8.51	8.91	9.87
	Mean	8.70	10.58	13.70	10.19	11.70	8.42
Ridomil	No Spray	6.93	8.53	12.09	7.16	11.71	11.16
	1week	11.60	13.82	17.31	13.51	16.67	6.02
	2weeks	9.98	12.40	13.69	12.16	15.27	7.13
	3weeks	9.20	11.33	14.13	14.11	14.56	8.18
	4weeks	7.67	9.96	12.98	8.98	11.80	9.98
	Mean	9.08	11.21	14.04	11.18	14.00	8.49
$LSD_{(0.05)}$ for comparing any 2 fungicides		0.90	1.10	1.30	0.96	1.21	1.82
$LSD_{(0.05)}$ for fungicides×Spray regimess		2.01	2.47	NS	2.14	NS	4.07
Seasonal effect							
Early season		8.13	9.80	12.76			
Late season		9.48	12.41	9.47			
LSD (0.05) For comparing 2 seasons		0.53	0.67	0.94			

DAP = Days after planting, RD+CHP = Ridomil plus Champ fungicide 50%:50% mixture w/w, $LSD_{(0.05)}$ = Least significant difference at 0.05 probability level, NS = Not significant at 0.05 probability level

ANOVA of disease incidence revealed significant ($P < 0.05$) variation among the fungicides at all trial periods in early season planting (Table3) At 90 DAP, Ridomil treated plots had the highest disease incidence compared to other fungicides options, while the least disease incidence was scored by the control treated plots. At 120 - 150 DAP, control treated plots consistently maintained the highest significant ($P < 0.05$) disease incidence with respect to other fungicides, and the lowest disease incidence were consistently recorded by the Ridomil treated plots. The effect of fungicide and the spray regimes interaction significantly ($P < 0.05$) varied on disease incidence at the trial periods except at 90 DAP in early season (Table 3). However, at 90 DAP, Ridomil+Champ50%:50% mixture at 4th weekly spray regime had the highest disease incidence, and the least disease incidence was scored by the control plots. At 120 – 150 DAP, control treated plots at all spray regimes; Ridomil+Champ 50%:50% mixture; and Ridomil both at No spray and 4th weekly spray regimes scored the highest disease incidence, and the least values scored by both Ridomil treated plots at all weekly spray regimes at the trial periods. In late season planting, Fungicides showed a significant ($P < 0.05$) effect on disease incidence at the trial periods except at 90 DAP as shown in Table 3. At 90 DAP, however, Ridomil+Champ (50%:50% mixture) had the highest values compared to other fungicides, and the least value was scored by the Ridomil treated plants. At 120 - 150 DAP, both untreated plants consistently had the highest significant ($P < 0.05$) disease incidence with respect to other fungicides, and the least values were scored by both Ridomil and Ridomil +Champ (50%:50% mixture) at the trial periods. The effect of fungicides and spray regimes had a significant ($P < 0.05$) difference on disease incidence except at 90 DAP (Table 3). At 90 DAP, Ridomil+Champ (50%+50% mixture) treated plots at 4th weekly spray regime had the highest disease incidence compared to other combined effects, and the lowest value was recorded by Ridomil treated plots at weekly spray regime. At 120 - 150 DAP, Ridomil+Champ (50%: 50% mixture) treated plots had the highest significant ($P < 0.05$) disease incidence compared with other interaction options, and the least values were obtained in Ridomil treated plots at weekly spray regimes. The seasonal effect on disease incidence significantly (P < 0.05) varied at all trial periods. At 90 DAP, late season significantly (P < 0.05) scored a higher value than early season. At 120 - 150 DAP, early season consistently had higher values than late season (Table3).

Table 3. Fungicide treatments, spray regimes and seasonal effect on disease incidence (%) of cocyam (*Colocasia esculenta L.*) at the stipulated Days after planting (DAP) in 2013 early and late planting season.

		Early season			Late season		
Fungicide Treatments	Spray Regimes	90DAP	120DAP	150DAP	90DAP	120DAP	150DAP
Control	No Spray	48.56(6.18)	83.40(9.13)	100.00(10.03)	88.90(8.99)	95.30(9.77)	95.30(9.77)
	1week	48.00(6.21)	86.30(9.31)	100.00(10.03)	88.90(8.99)	88.80(9.41)	88.10(9.36)
	2weeks	38.78(4.88)	80.80(8.97)	100.00(10.03)	88.90(8.99)	91.00(9.52)	91.40(9.55)
	3weeks	43.00(5.68)	84.20(9.17)	100.00(10.03)	99.20(9.99)	87.40(9.29)	87.40(9.29)
	4weeks	46.00(6.10)	86.30(9.29)	10.00(10.03)	99.20(9.58)	92.70(9.60)	92.80(9.60)
	Mean	44.87(5.81)	84.20(9.17)	100.00(10.03)	91.60(9.31)	91.00(9.52)	91.00(9.51)
RD+CHP	No Spray	46.67(6.13)	81.00(9.00)	97.44(9.89)	97.10(9.87)	96.90(9.86)	96.70(9.84)
	1week	50.00(6.56)	53.00(7.22)	49.89(6.91)	83.40(9.09)	25.70(4.92)	22.20(4.42)
	2weeks	49.22(6.52)	75.10(8.61)	97.22(9.88)	94.10(9.71)	57.10(7.41)	54.40(7.22)
	3weeks	51.11(6.49)	80.20(8.96)	96.44(9.84)	92.90(9.60)	74.00(8.44)	72.70(8.36)
	4weeks	56.11(7.19)	74.90(8.55)	96.44(9.83)	99.30(9.99)	79.90(8.87)	77.90(8.77)
	Mean	50.62(6.58)	72.80(8.47)	87.49(9.27)	93.40(9.65)	66.70(7.90)	64.80(7.72)
Ridomil	No Spray	50.22(6.68)	89.90(9.50)	100.00(10.03)	98.80(9.96)	85.60(9.20)	91.10(9.52)
	1week	48.56(6.40)	33.20(5.70)	40.89(6.27)	62.00(7.53)	15.80(3.63)	14.80(3.51)
	2weeks	55.67(7.00)	74.00(8.58)	89.89(9.49)	89.00(9.43)	48.60(6.78)	48.10(6.78)
	3weeks	52.67(6.79)	80.10(8.94)	98.78(9.96)	90.40(9.51)	69.30(8.24)	67.30(8.10)
	4weeks	48.56(6.34)	74.10(8.59)	100.00(10.03)	93.60(9.68)	71.20(8.35)	68.90(8.19)
	Mean	51.13(6.64)	70.30(8.26)	85.91(9.15)	86.90(9.22)	58.10(7.24)	84.40(7.22)
$LSD_{(0.05)}$ for comparing any 2 fungicides means		0.54	0.35	0.26	NS	0.51	0.53
$LSD_{(0.05)}$ for fungicides×Spray regimess		NS	0.77	0.59	NS	1.15	1.18
Seasonal effect							
Early season		48.9(6.34)	75.78 (8.63)	91.13(9.48)			
Late season		90.6 (9.38)	71.95(8.22)	71.28(8.15)			
LSD (0.05) for comparing 2 seasons		0.38	0.25	0.24			

DAP =Days after planting RD+CHP= Ridomil plus Champ fungicide 50% :50% mixture w/w, $LSD_{(0.05)}$ = least significant difference at 0.05 Probability level, NS=Not significant at 0.05 probability level, values in parentheses indicates the square root transformed values.

ANOVA result on disease severity significantly (P < 0.05) varied among the fungicides at the trial periods in both cropping seasons except at 150 DAP in late season planting as seen in Table 4. In early season planting, at 90 - 50 DAP, control treated plots consistently had the highest disease severity compared to other fungicides, and the least mean score disease severity values were scored by both Ridomil+Champ (50%:50% mixture) and Ridomil; at the sampling periods. The combined effect of fungicides and the spray regimes significantly (P < 0.05) varied on disease severity at the trial periods except at 150 DAP. At 90 - 120 DAP, the control treated plants scored the highest disease severity compared to other interactions , and the least disease severity were consistently scored by Ridomil treated plants at weekly spray regime across the sampling periods. At 150 DAP, however**,** both control plots and Ridomil+Champ (50%:50% mixture) 4th weekly spray recorded the highest disease severity, and the least disease severity was scored by Ridomil+Champ (50%:50% mixture) at weekly spray regimes. In late season cropping, fungicides significantly (P < 0.05) differed on disease severity at the trial periods except at 150 DAP as shown in Table 4. At 90 - 120 DAP, control treated plots consistently maintained the highest significant disease severity compared to other fungicides, and the least disease severity scores were consistently recorded in the Ridomil treated plots. At 150 DAP, however, control plots recorded the highest disease severity compared to other fungicides, and the least disease severity score was recorded on the Ridomil treated plots across at the sampling periods. The effect of fungicides and the spray regimes significantly (P < 0.05) differed on disease severity at the sampling periods except at 150 DAP. At 90 DAP, control treatment had the highest disease severity to other interaction effects, and the least disease severity was scored by Ridoml plots at weekly spray regime. At 120 DAP, both control and Ridomil treated plants at 3rd weekly spray, had the highest disease severity compared to other interaction options, and the least disease severity was recorded by the Ridomil treated plants at weekly spray regime across the trial period. However, at 150 DAP, Ridomil treated plots at weekly spray maintained the least disease severity score, and the highest disease severity was recorded by both control treated plots and Ridomil+Champ (50%:50% mixture) at No spray regimes at the sampling period. The seasonal effect on disease severity significantly (P < 0.05) differed at all sampling period .(Table 4). At 90 DAP, late season planting had a higher disease severity score compared to early season planting. . At 120 - 150 DAP, early season planting consistently scored a higher disease severity than late season planting at the trial periods.

Table 4: Fungicide treatments, spray regimes interaction and seasonal effect on disease severity of cocoyam (*Colocasia esculenta* L.) at the stipulated Days after planting (DAP) in 2013 early and late planting season

		Early season			Late season		
Fungicide Treatments	**Spray Regimes**	**90DAP**	**120DAP**	**150DAP**	**90DAP**	**120DAP**	**150DAP**
Control	No Spray	2.33 (1.68)	2.22 (1.65)	2.44 (1.69	3.11 (1.89)	1.89 (1.53)	0.78 (1.09)
	1week	2.11 (1.61)	2.11 (1.61)	2.44 (1.69)	3.11 (1.89)	1.67 (1.46)	0.88 (1.12)
	2weeks	2.00 (1.58)	2.33 (1.68)	2.56 (1.77)	2.89 (1.84)	1.89 (1.52)	0.88 (1.12)
	3weeks	2.00 (1.58)	.2.00 (1.57)	2.56 (1.73)	3.22 (1.92)	2.11 (1.60)	0.67 (1.03)
	4weeks	1.67 (1.46)	2.11 (1.61)	2.67 (1.77)	3.44 (1.98)	2.00 (1.57)	0.56 (0.98)
	Mean	**2.02 (1.58)**	**2.16 (1.62)**	**2.53 (1.72)**	**3.16 (1.91)**	**1.91 (1.53)**	**0.76 (1.07)**
RD+CHP	No Spray	1.89 (1.54)	2.00 (1.68)	2.22 (1.62)	3.33 (1.95)	1.78 (1.50)	0.88 (1.17)
	1week	1.00 (1.23)	1.00 (1.23)	0.78 (1.11)	1.56 (1.42)	0.44 (0.94)	0.22 (0.82)
	2weeks	1.11 (1.26)	1.00 (1.30)	2.56 (1.33)	2.11 (1.61)	1.11 (1.26)	0.44 (0.94)
	3weeks	1.33 (1.34)	1.00 (1.42)	2.56 (1.52)	2.11(1.60)	2.00 (1.57)	0.44 (0.92)
	4weeks	1.00 (1.23)	1.00 (1.42)	2.67 (1.56)	2.78 (1.81)	1.67 (1.46)	0.67 (1.05)
	Mean	**1.27 (1.32)**	**1.53 (1.41)**	**1.64 (1.43)**	**2.38 (1.68)**	**1.40 (1.34)**	**0.53 (0.98)**
Ridomil	No Spray	1.44 (1.38)	2.11 (1.61)	2.33 (1.66)	2.78 (1.81)	2.11 (1.61)	1.00 (1.23)
	1week	0.78 (1.11)	0.89(1.17	0.78 (1.11)	1.22 (1.29)	0.33 (0.86)	0.11 (0.76)
	2weeks	1.11 (1.26)	1.33 (1.34)	1.22 (1.30)	1.78 (1.50)	1.00 (1.21)	0.22 (0.82)
	3weeks	1.44 (1.38)	1.89 (1.53)	2.11 (1.60)	1.78 (1.50)	1.44 (1.38)	0.44 (0.94)
	4weeks	1.56(1.42)	1.78 (1.50)	1.78 (1.50)	2.78 (1.80)	1.4 4 (1.38)	0.78 (1.11)
	Mean	**1.27 (1.31)**	**1.60 (1.43)**	**1.64 (1.43)**	**2.07 (1.29)**	**1.27 (1.29)**	**0.51 (0.97)**
$LSD_{(0.05)}$ for		0.06	0.06	0.08	0.08	0..08	NS
$LSD_{(0.05)}$ for fungicides×spray regimess		0.13	0.14	N S	0.17	0.19	NS
Seasonal effect							
Early season		1.52 (1.40)	1.76 (1.49)	1.94 (1.543)			
Late season		2.53 (1.72)	1.53 (1.39)	0.60 (1.01)			
LSD (0.05)		0.04	0.04	0.06			

DAP =Days after planting RD+CHP= Ridomil plus Champ fungicide 50% :50% mixture w/w, LSD $_{(0.05)}$ = least significant difference at 0.05 Probability level, NS=Not significant at 0.05 probability level, values in parentheses indicates the square root transformed values.

Table 5: Fungicide treatments, spray regimes and seasonal effect on cormel and corm weight and total tuber yield per stand (kg/ha) of cocoyam (*Colocasia esculenta* L.) after harvest in 2013 early and late planting season

		Early season			**Late season**		
Fungicide Treatments	**Spray Regimes**	**Cormel /ha**	**Corm weight /ha**	**TtY/ha**	**Cormel/ha**	**Corm weight /ha**	**TtY/ha**
Control	No Spray	10044.	4587.	14631.	5911	4889	10800
	1week	8400	4356.	12756.	7600	5200	12800
	2weeks	9422.	4933	14356.	7156	5244	12400
	3weeks	9556.	4800.	14356.	7062	4800	11862
	4weeks	10133.	5111.	15244.	6667	5378	12044
	Mean	**9511.**	**4757.**	**14268.**	**6879**	**5102**	**11981**
RD+CHP	No Spray	12756.	5156.	17911.	5644	4578	10222
	1week	18889.	7711.	26600.	10267	4622	14889
	2weeks	15022.	6089.	21111.	8578	4311	12889
	3weeks	12400.	5689.	18089.	8311	3982	12293
	4weeks	15556.	6267.	21822.	6889	4267	11156
	Mean	**14924.**	**6182.**	**21107.**	**7938**	**4352**	**12290**
Ridomil	No Spray	13156.	6978.	20133.	6267	4311	10578
	1week	19876.	9111.	28987.	14622	5822	20444
	2weeks	17156.	6622.	23778.	11633	5511	17144
	3weeks	16000.	6400.	22400.	11422	5467	16889
	4weeks	16133.	6373.	22507.	8978	4711	13689
	Mean	**16464.**	**7097.**	**23561.**	**10584**	**5164**	**15749**
$LSD_{(0.05)}$ for comparing any 2 fungicide means		1813	829.1	2262.2 2262.2	1709.8	863.6	2395.7
$LSD_{(0.05)}$ for fungicides×Spray regimes		NS	NS	NS	NS	NS	NS
Seasonal effect							
Early season		13633	6012	19645			
Late season		8467	4875	13342			
LSD (0.05) for comparing 2 seasons		8467	488	1336			

DAP = Days after planting, RD+CHP = Ridomil plus Champ fungicide 50%:50% mixture w/w, $LSD_{(0.05)}$ = Least significant difference at 0.05 probability level, NS = Not significant at 0.05 Probability Level, TtY = Total tuber yield

ANOVA result on yield components as presented in Table 5 showed that yields per hectare significantly ($P < 0.05$) varied among the fungicides in both planting seasons. In early season, Ridomil treated plants recorded the highest values for cormels weight, corm weight and total tuber yield compared to other fungicides, and the least cormels weight, corm weight and total tuber yields were recorded by all control treated plants at harvest. The combined effect of fungicides and the spray regimes had no significant ($P > 0.05$) differences on yields/hectare at harvest. However, Ridomil treated plants at weekly spray consistently had the highest values for cormels weight, corm weight and total tuber yields, and the least cormels weight, corm weight and total tuber yields were consistently maintained by all control treated plants. In late season, Ridomil treated plots consistently recorded the highest significant ($P < 0.05$) cormel weight, corm weight and total tuber yields (kg/ha) compared to other fungicide options, and the least yield values were recorded by Ridomil + champ (50%:50% mixture) and control treated plants. The effect of fungicides and the spray regimes interaction had no significant ($P > 0.05$) variation on cormels weight, corm weight and total tuber yield (kg/ha). However, Ridomil treated plots at weekly spray recorded the highest values compared to other combined effects, and the least cormels weight, corm weight and total tuber yield/ha were recorded by Ridomil +Champ (50%:50% mixture) treated plots. The seasonal effect significantly ($P < 0.05$) varied on yield indices measured at harvest. Early season consistently produced a higher value for cormels weight, corm weight and total tuber yields (kg/ha) than late season at harvest.

DISCUSSION

The weather records showed that climate elements varied remarkably. These variations might be responsible for the difference in agronomic, disease response and yield parameters measured in both seasons. The study revealed mean maximum temperature of 28.67 - 28.55^{o}C in June to October which supported disease expression in cocoyam. NRCRI (2012) reported that taro leaf blight occurs mostly at earlier part of July-August. They also reported that taro leaf blight occurs when night temperature ranges between 20 – 22^{o}C and daily temperatures of 25 – 28^{o}C.

In the present study, foliar disease symptoms appeared first at 75 and 60 DAP in early and late cropping seasons, respectively. These were seen as small brown and water soaked lesions and sometimes with orange host exudation. This report was in line with the findings made by Onyeka (2011); Mbong *et al.*(2013); and NRCRI (2012).

Significant differences ($P < 0.05$) were revealed among the fungicides on growth parameters especially on number of leaves/stand Ridomil performed best among the fungicides followed by Ridomil+Champ. This might be due to the efficacy of the fungicides in checking taro leaf disease thereby promoting production of more leaves during the growth periods. NRCRI (2012) reported that one of the impacts of disease control on taro was to improve growth status of crop. Results in this study were in line with Ghosh and Sitansu (1991) who reported low plant growth on untreated field while copper based fungicide gave an impressive plant growth and taro leaf blight control. More leaves/stand were produced in control plots in late season at the later stage of the trial (150 DAP) compared to treated plots. This might be due to unconducive weather conditions for disease expression and severity which favoured crop growth unlike the early season planting. The unfavorable weather conditions (like high temperature and less rainfall that hinder disease expression during dry period) might promote more leaves on both treated and untreated cocoyam fields during the later phase of field trial in late season planting. This indicates that taro disease hinders cocoyam growth potential at a particular period of the year. Trujilo (1965) stated that taro disease was much related to temperature. Mbong *et al.* (2013) stated that during the last quarter of 2009, symptoms suggestive of taro leaf blight were observed on taro across many southern regions in Nigeria, followed by a disappearance of symptoms with onset of dry season, but reappeared on the onset of rainy season.

The significant variations in the number of leaves/stand by the fungicide and spray regimes could be attributed to climatic factors, cultural practices, cultivar characters and fungicide spray regimes. Growth depends on cultivar. Wilson (1984) reported that maximum plant height and leaf area growth occurred at five months after planting, while maximum number of leaves are more variable, and stated that maximum leaf numbers varied between 3-5 months after planting and depend on cultivar, cultural practices like time of planting and disease control and climatic factors especially temperature and rainfall.

The significant ($P < 0.05$) variations on disease incidence and severity at the trial periods in early and late season could be attributed to the fungicide potential difference and the prevailing weather conditions. Consequently, disease incidence and severity varied with cultivar, fungicides and weather conditions. The fungicides and their spray regimes significantly reduced disease incidence and severity and consequently increased the total yield in cocoyam cultivar. The reduction in the disease incidence and severity through fungicide and the spray regimes might have contributed largely to the positive and significant tuber yield increase and disease control. This thus, indicated the superiority of weekly spray of Ridomil and Ridomil + champ over the no spray control. Ridomil plus or Ridomil Mz 12% metalaxyl + 60% Mancozeh has been reported to control late blight – *Phytophthora infestans* effectively in potatoes and tomatoes in Cameroon (Fontem and Aighewi, 1993 ; Fontem *et al.*,1996 ; Fontem *et al*., 1998 ; and Fontem, 1996).

CONCLUSION AND RECOMMENDATION

This trial shows that taro leaf blight reduces taro leaf growth, plant growth and taro tuber yield/ha . In addition to adoption of high yielding resistant cultivar(s), weekly foliar spraying of Ridomil or Ridomil+Champ should be incorporated into taro leaf blight control through integrated disease management (IDM) in Nsukka, Nigeria.

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