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EFFECT OF CROPPING SEASON ON THE CONTROL OF TARO LEAF BLIGHT (*Phytophthora colocasiae*) OF COCOYAM (*Colocasia esculenta* L.) IN NSUKKA, SOUTH EASTERN NIGERIA

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ABSTRACT
Agronomic Practice through cropping season with fungicides spray were used to assess their effect on taro leaf blight which limits taro production in Nigeria since 2009. The field trials were conducted at the Department of Crop Science Research Farm, University of Nigeria, Nsukka in early and late cropping seasons in 2013. Field design was 2 x 3 x 3 factorial in randomized complete block design with three replications. The 18 treatment combinations which consisted of two cropping seasons; three cocoyam cultivars; and three fungicides. Parameters were determined on establishment percentage at 15 and 30 days after planting (DAP): number of leaves at 90, 120 and 150 DAP; disease incidence and severity at 90, 120 and 150 DAP; and yield attributes/ha, using combined analysis of variance (ANOVA) with Genstat. Results revealed significant ($P < 0.05$) variation on establishment percentage, disease incidence and severity on 0 - 4 scale and yield indices measured among the cultivar and in both seasons at all trial periods. It was observed that mean number of leaves had significant ($P < 0.05$) difference among the cultivars and fungicides except at 150DAP, respectively. The main effect of fungicides, however, showed no significant ($P < 0.05$) difference on establishment percentage at the sampling periods. It was also noted that the combined effect of season with cultivar and fungicides had no significant ($P \geq 0.05$) effect in all parameters measured at all trial periods except on disease incidence at 120 days after planting. Therefore, early season cropping and adequate plant nutrition with resistant cultivar should be adopted by farmers to reduce any dependence on chemical which are neither economically nor environmentally friendly.

KEY WORDS: *Colocasia esculenta*, Taro blight, Disease severity, Season and Nsukka.

INTRODUCTION

Protected cultivation mainly by planting season with fungicides has greatly improved crop production worldwide since 1960. However, despite, its spread use in developed tropical countries of USA, Asia, china and Europe, its use in developed tropical African countries is not wide spread. Cocoyam taro (*Colocasia esculenta* L.) is an important tuber crop after yam and cassava in Nigeria (Echebiri, 2004), with diverse forms of production. It can be produced on wet or dry land system with regular supply of water throughout the growing season either by rainfall or supplement irrigation. Taro can be planted at any time of year between April – July after rains has been well established; and also after early season cropping of maize, yam, cassava, eggplant and yellow pepper farm works has been done in Nsukka, agro-ecology. Recently, cocoyam production is seriously declining due to poor agronomic practice, climatic stress, socio- economic perceptions and above all, fungal disease known as Taro leaf blight caused by *phytophthora colocasiae* Rac. (NRCRI, 2012; Onyeka, 2011; and Trujilo, 1965). The epidemic of taro leaf blight may occur throughout the year during continuous rainy season over cast weather where night temperatures are 20 – 22ºC and daily temperatures of 25 - 28ºC with little seasonal variation (Trujilo, 1965, Mbong *et al.*, 2013), hence, resulting in rapid taro defoliation, death and heavy to total yield losses under favourable weather conditions. The need to protect crops against pests and disease is therefore, a crucial aspect of enhancing the crops production (Onyeka *et al*., 2008). Therefore, the primary aim of the study was to investigate the effect of cropping season on the control of taro leaf blight of taro cultivars in Nsukka, Southeastern, Nigeria.

MATERIALS & METHODS

Two field experiments were conducted in early cropping season (April –November) and late cropping season (July – December) of 2013 in the Department of Crop Science, Faculty of Agriculture Teaching and Research Farm, University of Nigeria, Nsukka. Nsukka is located at the humid forest/derived savannah regions of South Eastern

Nigeria (Latitude O6° 24' N, longitude O7° 24' E and 447 meter above sea level (m.a.s.l). The rainfall distribution pattern is bimodal with peaks in July and September, and short dry period around mid August (August break). The mean annual rain fall ranges between 1500 – 1900 mm with a mean maximum and minimum temperatures of 31°C and 29°C and relative humidity of 69 - 79%, respectively (Uguru *et al*., 2011). The soil is sandy clay loam classified as ultisol belonging to Nkpologu series (Nwadialor, 1989).

Experimental Design, Treatment and treatment allocation

The field experimental design was 2 x 3 x 3 factorial trial in randomized complete block design (RCBD) with three replications. The 18 treatment combinations which consisted of two cropping seasons (early and late cropping seasons) ; three cultivars of cocoyam (Nachi, Odogolo and Ugwuta) at average weight of 25-35g/cormel, three fungicides (Ridomil Gold plus (active ingredient (*a.i*) 6% Metalaxyl M and 60% copper), Ridomil+Champ Dp (a.i Copper hydroxide) 50%:50% mixture and Control). The rate of 2.25kg/ha (50g per 16 litres knapsack sprayer) was applied. Also, an insecticide (Attacke 2.5 Emulsifiable concentrate (EC) a.i lambdacyhalothrin 2,5 EC) at the rate of 800ml in 100 litres of water was included to check foliar insect pests attack like mealybugs, (*Planococcus spp*), Taro plant hopper (*Tarophagus proserpins*) and Taro aphids (*Myzus persicae*). The treatments were randomly allocated to plots in each block/replicate. Moreover, all sprays were done early in the morning hours when weather action (wind) was calm usually at the onset of disease symptom(s) at 75 and 60 days after planting (DAP) in early and late cropping seasons , respectively.

Cultural Operations

Research field was cleared, ploughed, harrowed and made into crest of mounds manually with hoe. Prior to mound preparation, 15 tonnes/hectare of well cured poultry manure was broadcast uniformly and incorporated into the soil. Cocoyam/cormels at average weight of 25-35g/ cormel/ mound were planted at 0.5m x 0.5 m intra x inter rows spacing and at 5 - 8 cm depth in the soil. The plant population of 100 stands /plot (40, 000/ha) was used. Weeding was carried out manually with hoe and hand picking as regularly as when necessary. The second dose of poultry manure (15 tonnes/per hectare) was applied at 7 weeks after planting (WAP), followed immediately by re-mounding at 8 weeks after planting (WAP) for proper cocoyam growths and development. The Cocoyam corms/ cormels were harvested manually with hoe at full maturity in November and December for early and late cropping, respectively. Agro-meteorological records for the year 2013 was obtained at Faculty of Agriculture, Meterorological Station, University of Nigeria, Nsukka as shown in Table 1

Data collection and Analysis

Data on the production traits and disease parameters were obtained from five randomly selected and tagged stands/plot at the central rows on establishment percentage at 15 and 30 days after planting (DAP), number of leaves, disease incidence, disease severity at 90, 120 and 150 DAP and tuber yields per hectare (ha) at harvest. Disease incidence (%) was estimated as a proportion of number of plants showing disease symptom (s) over total number of plants multiplied by 100% . Disease severity was scored on 5point scale (0 – 4scale) designed in the course of this study where ranges (%) was determined by total area of plant leaves blighted (infected) over total area of plant leaves multiplied by 100 (%) as described by Chaube and Pundhir (2005) as below:

$$Severity = \frac{Area\,of\;\;plant\,leaves\,blightend}{Total\;area\,of\;\;plant\,leaves} \times \frac{100}{1}$$

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 collected were subjected to combined analysis of variance (ANOVA) using GenStat Release 10.3DE software (2011). Fisher's least significant at 5% probability level (F-LSD) 0.05) was used to compare treatment means where F-test was significant as described by Obi (2002).

RESULTS

Result of weather records shown in Table 1 presented a marked variation of climate factors in the study sites in 2013. Rainfall distribution revealed bimodal pattern with peaks in May (188mm) and July (233mm).The highest mean monthly maximum temperature was recorded on February (32.86°C) and the least mean minimum monthly temperature was recorded in December (19. 39°C). The mean maximum and minimum temperatures were 29.54°C and 21.14°C for the year.

Establishment percentage (%)

Result of the effect of cultivar and fungicide treatments on establishment percentage at 15 and 30DAP as seen inTable2 showed that establishment percentage significantly (P < 0.05) varied among the cultivars. Ugwuta consistently scored the highest (65.56%) and (81.6%) establishment percentage compared to other cultivars, and the least values (13.4%) and (59.8%) establishment percentage were scored by Odogolo at all trial periods. On fungicide treatments, establishment percentage had no significant (P > 0.05) effect among the fungicide treatments at all trial periods. However, at 15 and 30DAP, Ridomil and Ridomil+ champ 50%: 50% mixture treated plots scored the highest (35.56%) and (75.8%) establishment percentage with respect to other fungicides, and the least (34.06% and (72.3%) were obtained by both control and Ridomil + Champ 50%:50% mixture and Ridomil treated plots, respectively. Result of main effect of cultivar and fungicides on number of leaves at 90, 120 and 150 days after plating (DAP) significantly (P < 0.05) varied at the sampling periods except at 150DAP, respectively (Table 2). Among the cultivars, at 90 and 120 DAP, Ugwuta and Nachi had the highest (11.36) and (12.13) number of leaves compared to others, and the least values (5.72) and (9.36) were consistently recorded by Odogolo at the trial periods.

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

Month	Total rainfall (mm)	Rainy days	Mean temperature (ºC)		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: Main effect of cultivars and fungicide treatments on establishment percentage (%) and number of leaves at stipulated Days after planting

Cultivar	Establishment Percentage		No of leaves/stand		
	15 DAP	30 DAP	90DAP	120DAP	150 DAP
Nachi	23.7 (4.72)	79.2 (8.89)	9.31	12.13	11.41
Odigolo	13.4 (3.50)	(59.8) (7.66)	5.72	9.63	11.95
Ugwuta	65.56 (8.09)	81.6 (9.04)	11.38	11.55	9.98
LSD(0.05)	0.31	0.22	0.65	0.82	NS
Fungicide Treatments					
Control	34.06 (5.39)	72.5 (8.43)	6.84	9.57	11.0
RD+CHP	34.06 (5.43)	75.8 (8.68)	9.45	11.14	11.0
Ridomil	35.56 (5.50)	72.3 (8.48)	10.13	12.60	11.2
LSD(0.05)	N.S	NS	0.65	0.82	NS

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

At 150 DAP, however, Odogolo had the highest (11.95) number of leaves with respect to others, and the least value (9.98) was recorded in Ugwuta cultivar. Among the fungicides, at 90-120 DAP, Ridomil treated plots significantly (P < 0.05) had the highest (10.13) and (12.60) number of leaves compared to others, while the least values were (6.84) and (9.57) were consistently recorded by Control treated plots .At 150DAP, however, Ridomil treated plots also had the highest value (11.27) number of leaves with respect to others, and least value (11.01) was obtained by Control treated plots. In both seasons, there was significant (P < 0.05) difference on establishment percentage during early and late cropping seasons in 2013 at 15 and 30DAP as shown in Table 3. At 15 and 30 DAP, late season planting consistently had the highest (35. 70%) and (79.50%) establishment compared to early season planting (32.70%) and (67.63%), respectively. The effect of season with cultivar and fungicide showed no significant (P > 0.05) effect on establishment percentage at all trial periods. However, at 15 DAP, early season and Ugwuta with. Ridomil+ Champ 50%: 50% mixture (w/w) had the highest (71.67%) establishment percentage compared to other interaction options, while the least value (8.00%) establishment percentage was obtained in early season and Odogolo with Ridomil + Champ 50%: 50% mixture (w/w) interaction effects. At 30 DAP, the highest (92.99%) establishment percentage was scored by the combined effect of late season and Nachi cultivar with control treated plots which was statistically similar to (91.00%) establishment percentage obtained in late season and Odogolo with Ridomil + Champ 50%: 50% Mixture, and the least value (43.00%) establishment percentage was scored by the early season and Nachi with Ridomil treated plots interaction. ANOVA of number of leaves/stand at all trial periods significantly ($P < 0.05$) varied in both seasons (Table 3). At 90 - 120 DAP, Late season recorded the highest (9.48) and (12.41) number of leaves/stand than early season (8.13) and (9.80) number of leaves. At 150 DAP, early season registered the highest (12.76) number of leaves/stand than late season (9.47) number of leaves at the study period, respectively. The combined effect of season with cultivar and fungicide effect showed no significant ($P > 0.05$) variation on number of leaves/stand at all trial periods in both seasons. However, at 90 – 120 DAP, both late season with Ugwuta and Ridomil treated plots recorded the highest (17. 83) and (15.48) number of leaves/stand with respect to other interaction options, and the least values (4.28) and (5.45) were obtained by late season with Odogolo and Ridomil+ Champ 50%: 50% mixture; and early season with Odogolo and Control treated plots, respectively. At 150 DAP, early season with Nachi and Ridomil +Champ 50% : 50% mixture recorded the highest (14.85) number of leaves/stand compared to other combined effects, while late season with Ugwuta and Ridomil + Champ 50% : 50% mixture recorded the least value with 5.72 number of leaves/stand in both seasons during the trial period as seen in Table 3.

TABLE 3: Effect of fungicide treatments on establishment percentage (%) and number of leaves at stipulated Days after planting (DAP) of three cultivars of cocoyam (*Colocasia esculenta* L.) in early and late cropping of 2013

			Establishment Percentage (%)		Number of leaves		
Season	Cultivar	Fungicide treatments	15DAP	30DAP	90DAP	120DAP	150DAP
Early	Nachi	Control	19.33(4.13)	65.33(8.05)	7.77	9.59	11.76
		RD+CHP	16.67(3.99)	71.67(8.46)	8.75	11.35	14.85
		Ridomil	20.00(4.36)	71.67(8.48)	9.09	10.99	13.43
	Odogolo	Control	9.67(2.72)	43.00(6.41)	5.19	5.45	11.56
		RD+CHP	9.00(2.83)	51.67(7.17)	7.35	8.83	14.19
		Ridomil	8.00(2.76)	47.67(6.89)	8.09	9.91	14.77
	Ugwuta	Control	70.67(8.42)	87.67(9.38)	6.91	7.76	8.27
		RD+CHP	71.67(8.46)	85.67(9.27)	10.01	11.57	12.07
		Ridomil	69.67(8.35)	84.33(9.20)	10.04	12.73	13.92
	Mean		32.74(5.11)	67.63(8.15)	8.13	9.80	12.76
Late	Nachi	Control	29.33(5.32)	92.00(9.61)	7.44	13.09	9.88
		RD+CHP	26.67(5.13)	91.00(9.56)	11.80	13.20	9.07
		Ridomil	30.00(5.43)	83.67(9.16)	11.03	14.59	9.48
	Odogolo	Control	17.33(4.13)	69.33(8.33)	4.75	11.60	11.33
		RD+CHP	18.67(4.32)	77.67(8.81)	4.28	10.07	10.48
		Ridomil	18.00(4.27)	69.73(8.36)	4.69	11.93	9.35
	Ugwuta	Control	58.00(7.60)	77.67(8.81)	8.99	9.93	13.27
		RD+CHP	61.67(7.86)	77.33(8.80)	14.51	11.83	5.72
		Ridomil	61.67(7.86)	76.67(8.76)	17.83	15.48	6.65
	Mean		35.70(5.77)	79.45(8.91)	9.48	12.41	9.47
$LSD_{(0.05)}$ for comparing any 2 seasons			0.25	0.18	0.53	0.67	0.94
$LSD_{(0.05)}$ for season× cultivar x fungicides			NS	NS	NS	NS	NS

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

TABLE 4: Main effect of cultivar and fungicide treatments on disease incidence (%) and severity at stipulated Days after planting (DAP) during early and late cropping

	Disease Incidence (%)			Disease Severity		
Cultivar	90DAP	120 DAP	150DAP	90 DAP	120 DAP	150 DAP
Nachi	58.8 (7.10)	71.50 (8.29)	79.16 (8.68)	1.97 (1.54)	1.38 (1.35)	1.16 (1.25)
Odogolo	53.3 (6.64)	64.14 (7.88)	76.98(8.60)	2.19 (1.61)	1.53 (1.40)	0.99 (1.17
Ugwuta	97.2 (9.87)	85.94 (9.11)	87.49 (9.17)	1.92 (1.53)	2.02 (1.56)	1.67 (1.39)
LSD (0.05)	0.47	0.31	0.29	0.05	0.05	0.07
Fungicide Treatments						
Control	68.2(7.56)	87.63 (9.33)	95.51(9.77)	2.59 (1.74)	2.03 (1.58)	1.64 (1.40)
RD + CHP	72.0 (8.11)	69.78 (8.18)	79.13 (8.50)	1.82 (1.50)	1.47 (1.38)	1.09 (1.20)
Ridomil	69.0 (7.93)	64.18 (7.75)	71.98 (8.19)	1.67 (1.44)	1.43 (1.36)	1.08 (1.20)
LSD(0.05)	0.47	0.31	0.29	0.05	0.05	0.07

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.

Disease incidence (%)

Result of main effect of cultivar and fungicide treatments on disease incidence and severity revealed significant (P < 0.05) difference at all sampling periods as shown in Table 4. On disease incidence, cultivars significantly (P < 0.05) differed on disease incidence. At 90 -150DAP, Ugwuta consistently scored the highest (97.2%) (85.94%) and (87.49%) disease incidence with respect to others, and the least (53.3%) (64.14%) and (76.98%) disease incidence were consistently maintained by Odogolo cultivar. Disease incidence significantly (P < 0.05) varied among the fungicides with Control; and both Ridomil treated plots consistently scoring the least (68.2%) (64.18%) and (71.98%) disease incidence compared to others, and the highest values (72.0%) (87.63%) and (95.51%) were scored in Ridomil+ Champ 50%: 50%mixture; and both Control at the trial periods, respectively. With respect to disease severity, the results of main effect of cultivar and fungicide treatments on disease severity showed significant (P < 0.05) variation among the cultivars and fungicides at all sampling periods as shown in Table 4. Among the cultivars, at 90 DAP, Ugwuta significantly (P < 0.05) scored the least (1.92) disease severity compared to other cultivars, and the highest (2.19) disease severity was scored in Odogolo. Moreover, Ugwuta cultivar consistently scored the highest (2.02) and (1.67) score on 0- 4 scale disease severity compared to others , and the least (1.38) and (0.97) disease severity score were obtained in Nachi ; and Odogolo cultivars at 120 - 150 days after planting, respectively. Disease severity varied (P < 0.05) significantly among the fungicides with control treated plots consistently scoring the highest (2.59) (2.03) and (1.64) scores on 0 - 4 scale disease severity with respect to other fungicides , and the least (1.67) (1.43) and (1.08) disease severity scores were consistently scored in Ridomil treated plots at all trial periods, respectively.

In both cropping seasons, ANOVA showed significant (P < 0.05) difference on disease incidence in early and late cropping seasons in 2013 at the study periods except at 120 DAP as presented in Table 5 At 90 DAP, late cropping season significantly (P < 0.05) scored a higher (90.6%) disease incidence than early season planting with 48.9% disease incidence during the trial period. At 120DAP, early season recorded a higher (75.78%) disease incidence which was statistically similar to (71.95%) disease incidence scored in late cropping season. At 150 DAP, early cropping season significantly (P < 0.05) scored a higher (91.13%) disease incidence than late season cropping (71.28%) during the trial period. The effect of season and cultivar with fungicides showed no significant (P > 0.05) effect on disease incidence throughout the trial periods in both seasons.

TABLE 5: Effect of fungicide treatments on disease incidence (%) and severity of three cultivars of cocoyam (*Colocasia esculenta* L.) at stipulated Days after planting in early and late cropping of 2013

			Disease incidence (%)			Disease severity		
Seaso	Cultivars	Fungicides	90DAP	120DAP	150DAP	90DAP	120DAP	150DAP
Early	Nachi	Control	18.5(3.91)	81.40(9.03)	100(10.03)	1.73 (1.49)	1.93 (1.55)	2.07 (1.60)
		RD+CHP	27.9(5.07)	74.13(8.56)	90.00(9.46)	1.20 (1.30)	1.27 (1.32)	1.13 (1.25)
		Ridomil	19.3(4.29)	65.67(8.06)	84.53(9.10)	1.07 (1.25)	1.47 (1.39)	1.20 (1.29)
	Odogolo	Control	16.1(3.50)	74.13(8.61)	100(10.03)	2.40 (1.69)	2.20 (1.64)	1.87 (1.53)
		RD+CHP	24.0(4.63)	60.80(7.75)	87.47(9.31)	1.33 (1.34)	1.53 (1.41)	1.40 (1..37)
		Ridomil	34.1(5.618)	65.47(8.05)	86.40(9.20)	1.53 (1.40)	1.53 (1.42)	1.60 (1.44)
	Ugwuta	Control	100(10.03)	97.13(9.88)	100(10.03)	1,93 (1.56)	2.33 1.68)	3.67 (2.04)
		RD+CHP	100(10.03)	83.60(9.09)	85.00(9.05)	1.27 (1.32)	1.80 (1.50)	2.40 (1.66)
		Ridomil	100(10.03)	79.67(8.70)	86.80(9.16)	1.20 (1.29)	1.89 (1.49)	2.13 (1.58)
	Mean		48.90(6.34)	75.78(8.63)	91.13(9.48)	1.52 (1.40)	1.76 (1.49)	1.94 (1.53)
Late	Nachi	Control	100(10.03)	87.13(9.28)	91.13(9.24)	3.33 (1.90)	1.33 (1.34)	1.13 (1.22)
		RD+CHP	99.6(10.01)	68.87(8.08)	64.27(7.65)	2.47 (1.71)	1.27 (1.30)	0.80 (1.11)
		Ridomil	87.3(9.28)	51.80 (6.77)	49.60(6.63)	2.20 (1.62)	1.00 (1.19)	0.60 (1.02)
	Odogolo	Control	74.9(7.87)	86.00(9.251)	86.53(9.28)	3.07 (1.88)	1.80 (1.50)	0.47 (0.95)
		RD+CHP	85.8(9.21)	49.60(6.80)	49.60(6.80)	2.67 (1.76)	1.07 (1.23)	0.27 (0.85)
		Ridomil	84.9(9.03)	48.87(6.81)	51.87(6.98)	2.13 (1.60)	1.07 (1.22)	0.33 (0.88)
	Ugwuta	Control	100(10.03)	100(10.03)	100(10.03)	3.27 (1.93)	2.60 (1.76)	0.67 (1.04)
		RD+CHP	94.7(9.74)	81.67(8.82)	80.47(8.73)	2.00 (1.55)	1.87 (1.51)	0.53 (0.98)
		Ridomil	88.6(9.35)	73.60(8.14)	72.67(8.05)	1.871.51)	1.73 (1.46)	0.60 (1.02)
	Mean		90.6(9.39)	71.95(8.13)	71.28(8.15)	2.53. (1.72)	1.53 (1.39)	0.60 (1.01)
$LSD_{(0.05)}$ for comparing any 2 Seasons			0.38	NS	0.24	0.04	0.04	0.06
$LSD_{(0.05)}$ for			NS	NS	NS	0.12	NS	NS

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.

However, at 90 DAP, early season and Ugwuta cultivar with all fungicide, late season and Nachi with control, late season and Nachi with control: late season and Ugwuta with control plots, respectively had the highest disease incidence (100%) compared to other interaction options, and the least (16.1%) disease incidence was observed in early season and Odogolo with control treatment. At 120 DAP, late season and Ugwuta with control non significantly scored the highest (100%) disease incidence compared to others, and the least (51.80%) disease incidence was scored in late season and Nachi with Ridomil treated combined effects. At 150 DAP, early season and all cultivar options with all control plots; late season and Ugwuta cultivar with control plots scored the highest (100%) disease incidence compared to others which was statistically similar to (91.13%) obtained in late season and Nachi with Control plots, and the least value (49.60%) disease incidence was scored by both late season and Odogolo with Ridomil+ Champ 50% : 50% mixture; and Nachi with Ridomil combined effect during the period of study. ANOVA of disease severity significantly (P < 0.05) varied in both seasons at all trial periods as seen in Table5. At 90 DAP, late season scored the highest (2.53%) disease severity than early season with 1.52 mean score on 0- 4 scale disease severity. At 120–150 DAP, early season consistently scored the highest (1.76) and (1.94) mean score disease severity than late season with 1.53 and 0.60 mean score disease severity, respectively in both seasons.

TABLE 6: Main effect of cultivars and fungicide treatments on cormel weight, corm weight and total tuber yield (kg/ha) at harvest

Cultivars	Cormel weight/ha	Corm weight/ha	Tty/ha
Nachi	8821	4940	13761
Odogolo	12228	7297	19524
Ugwuta	12102	4091	16193
F LSD (0.05)	1233	597.6	1636.3
Fungicide Treatments			
Control	8195	4930	13125
Rd+chp	11431	5267	16698
Ridomil	13524	6131	19655
LSD (0.05)	1233	597.6	1636.3

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

TABLE 7: Effect of fungicides on cormel weight, corm weight and total tuber yield (kg/ha) of three cultivars of cocoyam (*Colocasia esculenta* L.) after harvest during the early and late cropping of 2013.

Season	Cultivars	Fungicide	cormel/ha	Corm weight/ha	TtY/ha
Early	Nachi	Control	8453	4853	13307
		RD+CHP	12613	5760	18373
		Ridomil	11947	6064	18011
	Odogolo	Control	10400	5952	16352
		RD+CHP	16800	8347	25147
		Ridomil	19285	1040	29685
	Ugwuta	Control	9680	3467	13147
		RD+CHP	15360	4440	19800
		Ridomil	18160	4827	22987
	Mean		13633	6012	19645
Late	Nachi	Control	3973	3813	7787
		RD+CHP	7387	4827	12213
		Ridomil	8553	4320	12873
	Odogolo	Control	7253	6827	14080
		RD+CHP	8427	5109	13536
		Ridomil	11200	7147	18347
	Ugwuta	Control	9411	4667	14077
		RD+CHP	8000	3120	11120
		Ridomil	12000	4027	16027
	Mean		8467	4873	13340
LSD$_{(0.05)}$ for comparing any 2 seasons			1007.1	488.0	1336.1
LSD$_{(0.05)}$ for season× cultivars×fungicides			NS	NS	NS

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

The effect of season with cultivar and fungicides revealed no significant (P > 0.05) difference at all trial periods, except at 90DAP. At 90DAP, late season and Ugwuta with Control significantly (P < 0.05) scored the highest (3.27) disease severity score with respect to others, while early season and Nachi with Ridomil treated plots scored the least (1.07) score disease severity. However, at 120 - 150 DAP, late season with Ugwuta and control; and early season and Ugwuta with control non significantly (P > 0.05) scored the highest (2.60) and (3.67) score disease severity, respectively, and the least value(1.00) and (0.27) disease severity score on 0 - 4 scale disease severity were obtained by both late season and Nachi with Ridomil; and Odogolo with Ridomil+ Champ 50%: 50%mixture treated combined effect at the trial periods (Table 5).

Yield attributes

Result of the effect of cultivars and fungicide treatments on yields per hectare showed significant (P < 0.05) effect at harvest as shown in Table 6. Among the cultivars, Odogolo cultivar consistently produced the highest (12228kg/ha) (7297kg/ha) and (19524kg/ha) for cormels weight, corm weight and total tuber yield compared to other cultivars, and the least values were produced by Nachi (8821kg/ha), Ugwuta (4091kg/ha) and Nachi (13761kg/ha) for cormels weight, corm weight and total tuber yield, respectively .On fungicides, yields significantly (P < 0.05) varied among the fungicides with Ridomil treated plots consistently recording the highest (13524kg/ha) (6131kg/ha) and (19655kg/ha) for cormels weight, corm weight and total tuber yield, respectively, and the least values (8195kg/ha) (4930kg/ha) and (13125kg/ha) were recorded by all Control treated plots, respectively (Table 6). Yields in both seasons as influenced by the interaction of season and cultivar with fungicides significantly (P < 0.05) varied at harvest as presented in Table 7.The early season significantly (P < 0.05) had a consistent higher (13633 kg/ha) (6012kg/ha) and (19645 kg/ha) cormels weight/ha, corm weight/ha and total tuber yield/ha than late season with 846kg/ha,4873kg/ha and 1334kg/ha for cormels weight, corm weight and total tuber yield, respectively at harvest The effect of season and cultivar with fungicide showed no significant (P > 0.05) variation on yield indices in both seasons at harvest. However, early season and Odogolo with Ridomil treated plots consistently maintained the highest (19285kg/ha), 10400kg/ha) and (29285kg/ha) cormels weight, corm weight and total tuber yield (kg/ha) respectively compared to other combined effects, and the least values (3973kg/ha) (3120kg/ha) and 11120kg/ha) were obtained by the interaction of late season and Nachi with control; and the same season (late season); and both Odogolo with Ridomil+Champ50%:50%mixture for cormels weight, corm weight and total tuber yield(kg/ha) respectively in both seasons in 2013 at harvest (Table 7).

DISCUSSION

The agro meteorological data presented in the Table1 showed that the remarkable difference in weather factors might have contributed to the differences observed in agronomic traits, disease and yield parameters measured in c*olocasia esculenta* in both seasons .In this study, the maximum temperature recorded in June – October between 28.7 – 28· 5ºC indicates their support in disease expression in cocoyam taro. This agrees with NRCRI, (2012) that taro leaf blight (TLB) occurred mostly at the earlier part of July – September of the year. This result also supports other researchers that taro leaf blight (TLB) occurs when night temperatures are 21-22ºC and day temperature of 25 - 28ºC. Also taro leaf blight resulted to temperature related growth of the causal organism - *phytophthora colocasiae* Rac with the rapid growth during warm day, followed by slow growth during cooler night (Trujilo, 1965) Onyeka, 2011 and Mbong *et al*., 2013). The significant difference (P < 0.05) among the cultivars on establishment in both seasons could be attributed to the inherent cultivar variation and climatic factors. Ndeiz, (1990) stated that in seed establishment that even when all the seeds were planted at the same time not all of them will emerge at same the time, but could on average,made successful stand counts. Results of the study disagree with the report made by Ndeayo *et al*. (2012) that there was no significant difference on establishment percentage among the cultivars in both seasons. Findings from this study support those of Aighewi *et al*. (2001) and Ndeayo *et al*., (2013) who observed that variation of cultivars had effect on the sprout and establishment of yam. Similarly, Chikaleka *et al*., (2011) and Ndeayo *et al.* (2013) reported varietal differences on flowering intensity, number of day, to sprout, establishment count. In both seasons, the significant higher establishment percentage in late season could be due to conducive climatic factors and edaphic factors which may be good availability of adequate soil moisture and optimum temperature at the time of planting. Gaijri *et al*., (2002) stated that seed germination emergence is affected by soil water, soil air, temperature factors. The study showed that Ugwuta cultivar had the highest establishment percentage among the cultivars at 15 and 30DAP and in both seasons at 15 DAP in early season cropping, but Nachi scored the highest value during late season cropping at 30 DAP which indicates less viability, storability and susceptability of Ugwuta to rot, poor long storage for planting material and consumption purposes. The non significant variation on establishment percentage as influenced by fungicides treatments; season with cultivar and fungicide interaction could be attributed to no fungicide treatment at the time of study at 15 and 30 DAP in 2013. Findings showed that with adequate rainfall, good environment and viable seeds, seedling emergence and establishment are very similar on both treated and untreated plots. The significant variation on number of leaves among the cultivars and in both seasons might be due to climatic factors and genetic/ cultivar differences in growth habits. Growth is a net result of various interactions like soil properties, soil fertility and type, climatic factors of rainfall and temperature stress; cultural practices example, time of planting, weeding, tillage disease control and differences for leaves and petioles growth pattern (Channapagouder *et al*., 2008). Similarly, planting season and soil fertility, water stress and temperature stress during growth cycle may delay sucker formation and petiole length resulting to less number of leaves and plant height, respectively. Some cultivars may not produce much sucker(s) and long petiole at all even when all essential growth environments are adequately available. The observed variation was earlier reported by Ogbonnaya *et al*. (1983), Onwueme *et al*. (1991); and Ogbonna *et al*. (2013) who stated varietal differences across the cultivars. The significant variations among the fungicides on number of leaves might be due to fungicides potentials in improving crop growth. NRCRI (2012) reported that cocoyam growth can be improved with spray of Nordox, Ridomil and Kocide fungicides against Taro blight. The no significant effect by the combined effect of season and cultivar with fungicides might be due to no effect of season and cultivar with fungicides interaction options on the cultivars rather than genetic and climatic effects during the trial periods. The result agrees with the findings by Ashok and Saikia (1996) who reported that no significant variation on taro plant growth parameter at application of fungicides against taro leaf blight. Results showed that more leaves were produced in control plots in late season planting at the later stage of study (150 DAP) compared to treated plots. This might be due to unfavourable weather conditions for disease expression which favored crop growth at the later part of the year unlike the early cropping season. The unfavorable weather conditions especially less rainfall and high temperatures that hinder disease manifestation during the dry period might favour more leaves production in cocoyam fields during the field trial in late cropping season. This agrees with the report by Trujilo (1965) who reported that taro leaf blight diseases were much related to temperature conditions. Mbong *et al*., (2013) stated that at the last quarter of 2009 symptoms suggestive of taro blight were observed on taro plants in Southern States of Nigeria, followed by disappearance of the symptoms with onset of dry periods.

The variations of cultivars and fungicide treatments on disease incidence and severity might be attributed to the genetic differences and fungicide potency on reducing disease effect on crops. Mbong *et al*., (2013) reported that cultivars varied in their response to fungicides. Findings supported Ogbonna *et al.*, (2013) who stated that Ugwuta and Odogolo cultivars were the most susceptible cultivars of cocoyam to Taro leaf blight disease. Ooka (1983) and Jackson *et al*., (1980) reported that Ridomil (Metalaxyl) and Phosphorous acid are specific to Taro leaf blight however, results with fungicides can be variable The significant difference ($P < 0.05$) on disease incidence and severity in both seasons except at 120 DAP in early season could be due to the climatic conditions at the growing periods especially temperature and rainfall which control the disease and pests condition at the cropping season. This result was in support of the findings by Strivastavas *et al.* (1989) who stated that the period of rainy season (July – August) could also be a period of pests and disease attack from other crops. Further, Onyeka, (2012), Mbong *et al.* (2013) reported that during the last quarter 2009, symptom(s) suggestive of Taro blight affected cocoyam plants across many Southern states in Nigeria, followed by disappearance of symptoms with onset of dry season. The non significant effect on disease incidence as influenced by the effect of season x cultivar and fungicides might be attributed to the climatic factors and cultivar characters. Notwithstanding the least disease incidence in late cropping season, total tuber yield was observed higher in early season compared to late cropping season. This result was in collaboration with the report made by NRCRI, (2012) that early planting (April/May) and disease resistant cultivar with fungicide spray as one of the strategy to reduce disease incidence and improve yield package in the field.Yields variations ($P < 0.05$) among the cultivars and fungicides treatments could be due to genetic/cultivar differences and fungicide potentials. The yield superiority showed by Odogolo and Ugwuta in this trial was in line with findings by Ogbonna *et al*. (2013). Asadu (1996) reported that apart from location and fertilizer type, cultivar type significantly affects tuber yields. Chukwu *et al.* (2012) stated that yield can be improved with fungicides like Kocide, Ridomil and Nordox. The significant differences observed between early and late cropping season on yield parameters could be due to genetic potential, climatic factors and cultural practices at the time of planting. Similarly, soil fertility, soil moisture and temperature stresses may affect tuber formation during cormelization. In this study it was observed that less number of cormels, corm weight, cormels weight and total tuber yield (kg/ha) were recorded in late cropping season than early cropping season. The tuber formation occurs at 3 months after planting which suggest early cropping season to avoid the effect of dry period during the growth cycle. The higher yield in early cropping season in this study was in line with the findings by Onwueme and Singh (1991) who stated that most taro are usually planted at onset of rainy season so that they can utilize the entire season to grow and develop well. Further, NRCRI (2003 and 2012) stated that early planting (April/June) should be adopted in order to improve high yield package. The non significant effect as influenced by the season with cultivar and fungicide spray with early season and Odogolo with all Ridomil treated plots producing the most yield parameters measured. This result could be due to cultivar, environmental effects and fungicide potentials. The least yield obtained in late season in all cultivar and fungicide may be attributed to the report by NRCRI (2012) that taro disease occur in earlier part of July- September resulting to reduced growth, yield and total crop failure/hunger and poverty.

CONCLUSIONS & RECOMMENDATION

The trial shows that taro leaf blight decreases taro leaf growth, plant height, tuber yield and consequently net farm income. In addition to adoption of high yielding resistant cultivar(s), early cropping season with fungicide treatments through cocoyam control should be incorporated into integrated pathogens management (IPM) against taro leaf blight–*phytophthora colocasiae* Raciborski in view of reducing fungicides. Therefore, early cropping season and adequate plant nutrition with fungicide spray should be recommended to farmers against taro leaf blight impact .The three cultivars tested maintained a promising high yields, despite, the outbreak of Taro blight in both seasons which suggest their stable performance, therefore, should be recommended to farmers in Nsukka, agro - ecology, Nigeria.

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