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EVALUATION OF SELECTED SOIL ORGANIC AMENDMENTS FOR THE CONTROL OF COCOYAM ROOT ROT BLIGHT COMPLEX (CRRBC) IN UMUDIKE

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Abstract

Soil-borne diseases are the second most important limiting factor on crop yield after water insufficiency. *Xanthosoma* spp production systems in particular are plagued by many intractable soil-borne diseases, like cocoyam root rot blight complex (CRRBC). A trial was conducted in Umudike, South-East Nigeria to determine the effect of selected organic amendment composts on the growth and yield parameters of *Xanthosoma sagittifolium* (NXs 002-*Ede Uhie*) and to evaluate their effect on CRRBC incidence and severity under Umudike conditions. The experiment was set up in a split plot treatment fitted into a randomized complete block design (RCBD), at the Western Farm of National Root Crops Research Institute's (NRCRI) Farm, Umudike, South-East Nigeria. Organic amendment composts [poultry manure compost (PMC), cow dung compost (CDC), swine dung compost (SDC), and rice mill waste compost (RMWC)] occupied the main plots, while rates of amendment (0, 4, 8 t/ha) occupied the sub-plots. Treatments were replicated three times. Planting was done on plots measuring 2m x 4m and at a spacing of 0.50m within rows and 0.50m between rows. Composted organic amendments treatments were applied 2 weeks after sprouting. Blanket application of inorganic fertilizer (400kg/ha, NPK 15:15:15) was applied 6 weeks after planting (WAP). Plots were manually kept weed-free. Relevant agronomic and pathological data were collected. All compost amendments improved growth parameters better than RMWC. Tallest plants were obtained from control plots which were attributed to improved plant nutrition by the blanket application of inorganic fertilizer. Highest corm yield and reduction in disease levels occurred in CDC amended plots. Application of 8 t/ha CDC improved yield and yield parameters, and reduced CRRBC incidence and severity of *Xanthosoma sagittifolium* (NXs 002 *Ede Uhie*) under Umudike conditions.

Keywords: Cocoyam root rot blight complex (CRRBC), Disease incidence and severity, Organic amendment composts, and *Xanthosoma spp.*

Introduction

Soil-borne diseases are the second most important limiting factor on crop yield after water insufficiency. *Xanthosoma spp* production systems in particular are plagued by many intractable soil-borne diseases like cocoyam root rot blight complex (CRRBC). The name CRRBC, according Chukwu *et al.* (2011) arose out of conflicting research investigations on its etiology, where various causal organisms were implicated, such as *Sclerolium rolfsii* (Arene and Okpala, 1981), *Pythium myriotylium*, *Rhizoctonia stolonifer* (Okeke, 1981), *Fusarium solani* and *Phytophthora infestans* (Arene and Okpala, 1981). Arene and Ofoegbu (1984) had also identified *Pythium spp*, *Fusarium* and *Rhizoctonia solani* in CRRBC of *Xanthosoma spp*. Infected plants become chlorotic and weak, which affect crop growth, vigour, tuber quality and yield. Chukwu *et al.* (2011) reported that previous efforts to tackle the disease through the use of high potassium (K) fertilizer (Nnoke *et al*., 1987), time of planting (Igbokwe, 1981), and intercropping (Odurukwe and Enyinnaya, 1987) were not effective. The management of CRRBC has often resulted in the use of soil fumigants, which have potential to be detrimental to beneficial soil-borne organisms. Some authors have demonstrated the enhancement of soil suppression by both composted and un-composted amendments (Aryantha *et al*., 2000). Several studies indicated that composted materials are more suppressive to root rots than un-composted (Hoitink and Boehm, 1999; Snapp *et al*., 2016). Malandraki *et al*. (2008) and Tamm *et al*. (2010) have consistently demonstrated suppressive effect of composted amendments on soil-borne diseases, such as damping-off and root rot (caused by *Pythium ultimum*, *Rhizoctonia solani*, *Rosellinia necatrix*, *Phytophthora spp*) and wilts (caused by *Fusarium oxysporum* and *Verticillium dahlia*) in a wide range of crops. A trial was conducted to ascertain the effectiveness of some organic amendment composts on the performance of *Xanthosoma sagittifolium* (NXs 002-*Ede Uhie*) and on CRRBC incidence and severity under Umudike condition.

Materials and Methods

The experiment was set up in a split plot treatment arrangement, in a randomized complete block design (RCBD) at the Western Farm of NRCRI Research Farm in Umudike, South-East Nigeria (Latitude 05^{o} 29′ N; Longitude 07^{0} 33′ E and altitude 122m). Organic amendment composts [poultry manure compost (PMC), cow dung compost (CDC), swine dung compost (SDC), and rice mill waste compost (RMWC)] occupied the main plots, while rates of amendment (0, 4, 8 t/ha) occupied the sub-plots. Treatments were replicated three times. Initial soil samples were collected from 5 representative sites of the field at a soil depth of 0 – 30cm before planting. Composite soil sample was bagged and taken to NRCRI Soil Laboratory for determination of physico-chemical properties. Planting was done on plots measuring 2m x 4m and at a spacing of 0.50m within rows and 0.50m between rows. Composted organic amendments treatments were applied 2 weeks after sprouting. Inorganic fertilizer was applied 6 weeks after planting (WAP) on all treatment plots at the rate of 400kg/ha (NPK 15:15:15). Plots were manually kept weed-free. Relevant agronomic and pathological data were collected.

Analysis of physico-chemical properties of the study soil

Total N was determined by the macro-Kjeldahl digestion method (Bremner and Mulvaney, 1982). Particle size distribution was measured by the hydrometer method as described by Gee and Bauder (1986). Organic carbon was determined by the dichromate oxidation method of Walkley and Black (Nelson and Sommers, 1982). Organic matter (OM) was determined by multiplying organic compost (OC) expressed in percentage with the conventional Van Bernmeller factor of 1.724. Soil pH (H_2O) was measured (soil/water ratio of 1:2.5) with a digital pH meter (McLean, 1982). Available P was determined by the Bray 2 method according to Bray and Kurtz (1945). Cation exchange capacity (CEC) was determined by the NH_4OAc displacement method (Thomas, 1982) and exchangeable K in extract estimated by flame photometry. Exchangeable acidity was determined by the titrimetric method after extraction with 1.0 M KCl (McLean, 1982). Effective cation exchange capacity (ECEC) was determined by the sum of the exchangeable bases and the exchangeable acidity.

Analysis of variance (ANOVA)

Analysis of variance (ANOVA) for a split plot experiment fitted into RCBD was carried out to establish the treatment(s) and treatment interaction(s), that significantly ($P < 0.05$) improved growth and yield of *Xanthosoma*, and disease suppression. Significant treatment means were separated using F-LSD at 5% probability level.

Results and Discussion

The soil physico-chemical properties of the experimental site are as shown in Table 1. The particle size distribution showed that the soil had a loamy sand texture and a soil reaction that was strongly acidic (5.4). Soil OM, N and effective CEC were low (12.93g/kg, 0.83g/kg and 3.98cmol/kg respectively). Available phosphorus was medium in the study soil (24.4mg/kg). Nwokocha *et al*. (2011) reported similar low nutrient status for sandy loam soil at Umudike.

Results obtained from the study showed that organic compost amendment significantly affected plant height, stem girth and leaf number/plot at 2MAP ($P < 0.01$) and at 4MAP ($P <0.05$) (Table 2). All organic compost amendments improved growth parameters better than RMWC at both 2 and 4MAP. Rate of amendment significantly ($P < 0.01$) influenced plant height at 2 and 4MAP, stem girth at 2 and 4MAP and total leaf number at 4MAP (Table 2). Application of 8t/ha organic compost amendment suppressed plant height at 2 and 4MAP by 20.0 and 18.6%, respectively. Highest growth in plant height was observed in the control plots (0t/ha) at 2MAP (35.1cm) and 4MAP (41.9cm), and stem girth at 2MAP (10.7cm). This may be attributed to the effect of the blanket application of NPK fertilizers, which may not have caused nutrients immobilization in the control plots, relative to other plots that received organic amendments, and therefore promoted both primary and secondary growth of cocoyam in the control plots. Amendment *x* rate interaction effects showed that increase in rate of CDC at 8t/ha relative to the control (CDC x 0t/ha) increased plant height by 19.6% (2MAP) and by 17.5% (4MAP), stem girth by 9.1% (2MAP) and by 68.4% (4MAP), and leaf number per plot by 32.2% (2 MAP), and by 94.5% (4MAP) (Table 2). Application of 8t/ha PMC consistently depressed plant height at 2 and 4MAP by 33.3 and 38.4%, respectively. Similar results were obtained with 8t/ha application of SDC at 2 and 4MAP (51.4% and 35.8%, respectively). It was observed that application of 8t/ha CDC improved measured growth parameters, while 8t/ha SDC caused a reduction in growth parameters, except stem girth at 2MAP.

Cow dung compost recorded (Table 3) significantly lower numbers of cormels (35914/ha) and total tuber number (80628/ha), when compared with values obtained from other amendments. However, corms yield (4.77t/ha) due to application of CDC was significantly ($P < 0.05$) higher than values obtained from PMC (3.87t/ha), RMWC (3.43t/ha) and SDC (3.85t/ha), which did not differ from each other. Yield and yield parameters increased with increase in rate of amendments applied (Table 3). Effect of rate of amendment could not establish an optimum rate as yields were increasing with increase in rates of amendment. Results of amendment *x* rate interaction showed that application of RMWC *x* 8t/ha yielded significantly ($P < 0.01$) highest total tuber number (142667/ha), which however, did not differ significantly with values obtained from SDC *x* 4t/ha (131515/ha), CDC x 8t/ha (117222/ha) and PMC x 4t/ha (115960/ha) interaction plots. Significant (P < 0.01) highest total tuber yield (8.79 t/ha) was obtained from CDC *x* 8t/ha interaction plot (Table 3).

Cocoyam root rot blight complex incidence (%) and severity increased with increase in months of observation (Table 4). Cow dung compost plots consistently recorded lowest percentage disease incidence and severity, except disease incidence at 2MAP, where PMC plots recorded the least values (24.9%) (Table 4). Amended plots recorded lowest reduction in disease incidence and severity. This reduction was higher in plots amended with 4t/ha amendment. Cow dung compost at the rate of 8t/ha, consistently reduced disease incidence and severity at 2MAP by 34.6 and 33.3% respectively, and at 4MAP by 37.6 and 32.5%, respectively. Application of PMC at 8t/ha recorded significantly (P < 0.01) highest percentage reductions in disease incidence and severity (41.3 and 45.9%, respectively) at 2MAP. However, at 4MAP, the treatments combination caused highest percentage increases in disease incidence (71.7%) and severity (11.1%). This result may suggest a change in the microbial community structure of PMC *x* 8t/ha plots at 4MAP. Bonilla *et al.* (2012) reported that the ability of different organic composts to suppress or promote diseases depend on the type of organic matter, plant host and pathogen species involved. Bonanomi *et al.* (2007) and Delgado *et al.* (2010) had reported that some organic amendments increase disease levels in crops.

Conclusion

All compost amendments improved growth parameters better than RMWC. Tallest plants were obtained from control plots which were attributed to improved plant nutrition by the blanket application of inorganic fertilizer. Highest corms yield and reduction in disease levels occurred in CDC amended plots. Application of 8t/ha CDC improved yield and yield parameters, and reduced CRRBC incidence and severity of *Xanthosoma sagittifolium* (NXs 002-*Ede Uhie*) under Umudike condition.

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Table 1: Soil physico-chemical properties before treatment application

Properties	Values
Sand (g/kg)	808.0
Silt (g/kg)	84.0
Clay (g/kg)	108.0
Texture[a]	LS
pH(H_2O)	5.42
ECEC[b] (cmol/kg)	3.98
Organic carbon (g/kg)	7.5
Organic matter (g/kg)	12.93
Total N (g/kg)	0.84
Available P (mg/kg)	24.4
Exchangeable K (cmol/kg)	0.102
C/N ratio	8.93

a. LS = Loamy sand; b. ECEC = Effective cation exchange capacity

Table 2: Effect of organic amendment, rate of amendment and amendment x rate interaction on the growth parameters of *Xanthosoma* cocoyam (NXs 002-*Ede Uhie*)

	Plant height (cm)		Stem girth (cm)		Leaf No/plant	
Treatment	**2 MAP**	**4 MAP**	**2 MAP**	**4 MAP**	**2 MAP**	**4 MAP**
Organic amendments compost						
CDC	30.9	44.3	9.25	6.77	3.91	1.95
PMC	26.7	45.9	12.14	6.59	3.67	1.95
RMWC	19.9	37.9	7.52	4.91	2.70	1.57
SDC	42.3	46.2	8.50	5.43	3.69	1.99
LSD (0.05)	**4.8****	**4.6***	**0.88****	**1.12***	**0.59****	**0.24***
Rates of amendment (t/ha)						
0	35.1	47.9	10.70	6.11	3.44	1.81
4	26.6	43.8	8.98	5.03	3.54	1.36
8	28.1	39.0	8.67	6.63	3.50	2.41
LSD (0.05)	**5.21****	**3.8****	**0.64****	**0.78****	**NS**	**0.28****
Amendment *x* rate interaction						
CDC x 0 t/ha	27.0	36.1	7.94	4.87	3.11	1.46
CDC x 4 t/ha	33.3	54.3	11.14	7.23	4.50	1.54
CDC x 8 t/ha	32.3	42.4	8.66	8.20	4.11	2.84
% increase	**19.6%**	**17.5%**	**9.1%**	**68.4%**	**32.2%**	**94.5%**
PMC x 0 t/ha	33.0	53.9	17.25	6.83	4.25	1.84
PMC x 4 t/ha	25.0	50.5	9.92	5.50	3.17	1.75
PMC x 8 t/ha	22.0	33.2	9.25	7.44	3.59	2.25
% increase	**-33.3%**	**38.4%**	**-46.4%**	**8.9%**	**-15.5%**	**22.3%**
RMWC x 0 t/ha	24.5	45.1	10.62	6.17	3.23	1.63
RMWC x 4 t/ha	4.3	24.4	5.12	2.00	1.50	0.67
RMWC x 8 t/ha	30.9	44.3	8.00	6.56	3.38	2.42
% increase	**26.1%**	**-1.8%**	**-24.7%**	**6.3%**	**4.6%**	**48.5%**
SDC x 0 t/ha	56.0	56.5	7.00	6.57	3.17	2.34
SDC x 4 t/ha	43.8	45.9	9.75	5.37	5.00	1.50
SDC x 8 t/ha	27.2	36.3	8.75	4.33	2.92	2.13
% increase	**-51.4%**	**-35.8%**	**25.0%**	**-34.1%**	**-7.9%**	**-9.0%**
LSD (0.05)	**9.3****	**7.2****	**1.27****	**1.57****	**0.84****	**0.49****

***, ** = Significant at 5 and 1% probability levels, respectively; NS = Not significant at 5% probability level.**
% increase = (Value at 8 t/ha amendment rate/value at 0 t/ha) – 1) *100

Table 3: Effect of organic amendment, rate of amendment and amendment x rate interaction on yield and yield parameters of Nigerian *Xanthosoma* cocoyam (NXs 002-*Ede Uhie*)

Treatments	Corms No/ha	Cormels No/ha	Total tuber No/ha	Corms yield (t//ha)	Cormels yield (t/ha)	Total tuber yield (t/ha)
Organic amendments compost						
CDC	44714	35914	80628	4.77	0.92	5.69
PMC	41448	61556	103003	3.87	0.87	4.75
RMWC	39556	60654	100210	3.43	0.91	4.34
SDC	39407	55434	94842	3.85	0.96	4.81
LSD (0.05)	**NS**	**12918****	**13009***	**0.67***	**NS**	**NS**
Rates of amendments (t/ha)						
0	41139	32130	73269	2.79	0.79	3.58
4	41888	54591	96478	4.15	0.58	4.73
8	40817	73448	114265	5.00	1.38	6.38
LSD (0.05)	**NS**	**11902****	**12725****	**0.54****	**0.22****	**0.64****
Amendment x rate interaction						
CDC x 0 t/ha	39963	33111	73074	4.12	0.71	4.83
CDC x 4 t/ha	45794	5794	51587	3.28	0.18	3.46
CDC x 8 t/ha	48386	68836	117222	6.93	1.86	8.79
% increase	**21.1%**	**107.9%**	**60.4%**	**68.2%**	**162.0%**	**82.0%**
PMC x 0 t/ha	44444	38667	8311	2.32	0.55	2.87
PMC x 4 t/ha	41111	74848	115960	5.97	0.92	6.89
PMC x 8 t/ha	38788	71152	109939	3.34	1.14	4.48
% increase	**-12.7%**	**84.0%**	**1222.8%**	**44.0%**	**107.3%**	**56.1%**
RMWC x 0 t/ha	44444	26667	71111	2.49	0.93	`3.42
RMWC x 4 t/ha	35556	51296	86852	2.59	0.14	2.73
RMWC x 8 t/ha	38667	104000	142667	5.21	1.65	6.86
% increase	**-13.0**	**290.0**	**100.6%**	**109.2%**	**77.4%**	**100.6%**
SDC x 0 t/ha	35704	30074	65778	2.23	0.95	3.19
SDC x 4 t/ha	45091	86424	131515	4.77	1.08	5.85
SDC x 8 t/ha	37428	49805	87232	4.54	0.85	5.39
% increase	**4.8%**	**65.6%**	**32.6%**	**103.6%**	**-10.5%**	**69.0%**
LSD (0.05)	**7130***	**21944****	**23141****	**1.03****	**0.56****	**1.37****

***, ** = Significant at 5 and 1% probability levels, respectively; NS = Not significant at 5% probability level. % increase = (Value at 8 t/ha amendment rate/value at 0 t/ha) – 1) *100**

Table 4: Effect of amendment, rate of amendment and amendment x rate interaction on the incidence and severity of CRRBC of *Xanthosoma* (NXs 002-*Ede Uhie*)

	Disease incidence (%)		Disease severity	
Treatment	**2 MAP**	**4 MAP**	**2 MAP**	**4 MAP**
Organic compost amendments				
CDC	29.7	37.9	2.7	3.1
PMC	24.9	42.3	2.6	3.1
RMWC	31.7	48.6	2.8	4.0
SDC	28.4	44.8	2.6	3.1
$LSD_{(0.05)}$	3.8*	6.8*	NS	0.6*
Rate of amendment (t/ha)				
0	33.9	47.7	3.2	3.7
4	24.2	40.7	2.4	3.3
8	27.8	41.8	2.3	3.0
$LSD_{(0.05)}$	2.3**	4.5**	0.2**	0.3**
Amendment x Rate interaction				
CDC x 0 t/ha	34.7	52.1	3.0	4.0
CDC x 4 t/ha	31.6	29.1	3.0	2.7
CDC x 8 t/ha	22.7	32.5	2.0	2.7
% increase	**-34.6%**	**-37.6%**	**-33.3%**	**-32.5**
PMC x 0 t/ha	34.9	27.9	3.7	2.7
PMC x 4 t/ha	19.2	51.0	2.0	3.7
PMC x 8 t/ha	20.5	47.9	2.0	3.0
% increase	**-41.3%**	**71.7%**	**-45.9%**	**11.1%**
RMWC x 0 t/ha	31.6	42.1	3.0	4.0
RMWC x 4 t/ha	24.9	44.3	2.3	4.0
RMWC x 8 t/ha	38.6	59.4	3.0	4.0
% increase	**22.2%**	**41.1%**	**0.0%**	**0.0%**
SDC x 0 t/ha	34.3	68.7	3.0	4.0
SDC x 4 t/ha	21.2	38.3	2.3	3.0
SDC x 8 t/ha	29.5	27.3	2.3	2.3
% increase	**-14.0%**	**-60.3%**	**-23.3%**	**-42.5**
$LSD_{(0.05)}$	4.9**	9.2**	0.6**	0.7**

***, ** = Significant at 5 and 1% probability levels, respectively; NS = Not significant at 5% probability level. % increase = (Value at 8 t/ha amendment rate/value at 0 t/ha) – 1) *100**