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Responses of Growth, Yield, and Disease Assessment Indices of Tannia [*Xanthosoma Sagittifolium* (L) Schott] to Plant Spacing and Manure Sources in Umudike

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Abstract

A field study was conducted for three consecutive years to investigate the effect of plant spacing and manure sources on growth, yield and disease assessment indices of tannia [*Xanthosoma sagittifolium* (L) schott] at the Forestry Research Institute of Nigeria, Eastern Research Station, Umuahia. A piece of land measuring 11m x 20 m was cleared and prepared for beds of plot sizes of 4 m x 3 m with a space of 1.0 m and 0.50 m between and within plots, respectively. The experiment was laid out in a 3 x 3 factorial fitted into Randomized Complete Block Design (RCBD) in which Factor A comprised three organic manure sources (control, poultry and goat manures of 5 t ha^{-1} each while Factor B formed three planting spaces (1.0 m x 0.30 m, 1.0 m x 0.40 m and 1.0 m x 0.50 m) with 33333, 25000 and 20000 ha^{-1} plant densities, respectively. There was a total of nine treatment combinations with three replicates. Cormels of equal sizes were planted in June in each of the three years. The results showed that there were no significant main and interaction effects of plants spacing and manure sources on leaf area, leaf area index, dry matter production, harvest index and disease incidence of tannia.

Keywords: Tannia, manure sources, plant spacing, LAI, cocoyam root rot blight complex.

Introduction

Tannia (*Xanthosoma sagittifolium)* known as new cocoyam originated from central and south America before reaching south-east Asia, Pacific Islands and Africa (Titus, 2008; Udoh and Ndon, 2016). Tannia belongs to the family of Aracea alongside with *Colocasia esculenta*, *Amorphophallus paeoniifolious*, *Alocasia macrorrliza* and *Cyrtosperma merkusii*, although *Xanthosoma sagittifolium* and *Colocasia esculenta* form the main edible aroids while others are of less economic importance in Africa (Owusu-Darko *et al*., 2014). Tannia (*Xanthosoma/Zanthosoma sagittifolium)* has many other species, the major include *Xanthosoma robustum, Xanthosoma atrovirens, Xanthosoma violaceum, Xanthosoma mafaffa Aurea, Xanthosoma albo-marginata, Xanthosoma sagittifolium, Xanthosoma brasiliense,* etc, (*Xanthosoma* Wikipedia, 2014). Since cocoyam tolerate shade, the crop plants are usually sown in intercropping systems together with perennial crops such as banana, coffee, coconut, rubber, oil palm. Cormels of cocoyam which form the main economic parts contain about 15-39 % carbohydrates, 2-4 % protein and 70-77 % water (Ndon *et al.,* 2003).

The young leaves contain 2% protein and are also rich in vitamin C, thiamine, riboflavin, niacin, calcium, phosphorus, and iron (Ndon *et al.,* 2003). The corms and cormels of the crop are of important source of carbohydrate for human nutrition, animal feed and income for farmers (Ojeniyi *et al.,* 2013). Cocoyam may be boiled, baked, steamed, creamed, fried, mashed, used in soups, chowders, stews, salads, or made into flour or meal for pastry which is stuffed with meat or other fillings (Owusu- Darko *et al*., 2014). Cocoyam is nutritionally superior to cassava and yam and taro starch is also more readily digested (NRCRI, 2010). Antony and Veerabahu (2012) reported that *Xanthosoma sagittifolium* contains phenols and flavonoids which possess antioxidant properties that can exhibit a variety of beneficial biological properties like anti-inflammatory, anti-tumor and anti-microbial activities in the body. In Afikpo South, tannia cormels are cooked with common beans as porridge. They can also be cooked and eaten with specially prepared palm oil (i.e. Palm oil into which little water and potash have been added) called *Ngu*. Hailu and Sue (2011) defined plant spacing as the growing of crop plant, on a plot of land with sufficient space between each of the plants so that they can develop their roots and shoots more fully. Plant response to spacing varies among species and is highly dependent on such environmental conditions as soil characteristics, biotic elements and climatic conditions of the site.

Generally, cocoyam just like a rhizomatous crop plant and when planted produces a good number of suckers which develop into full plantlets. Hence, the expected plant population at planting would always be less than the population at maturity due to the emergence of these plantlets (Ogbonna *et al.,* 2015). A study conducted on taro cultivars in two locations using three plant spacings (1.0 x 0.30 m, 1.0 x 0.40 m and 1.0 x 0.50 m) by Ogbonna *et al.* (2015) showed that the closest planting spaces of 1.0 m x 0.30 m produced the highest tuber yield ha^{-1} among the three planting spaces in the two locations. Onwueme and Sinha (1991) reported that manure sources are associated with problems relating to unavailability, low quality depending on the type of transportation and handling problems, high C: N ratio, heavy metal pollution and slow nutrients release. Onwueme (1978) also reported that cocoyam requires a lot of potassium which in the traditional farming system is found in ash left after bush burning. Chukwu and Eteng (2014) recorded a significantly higher yield of *Xanthosoma mafaffa* with application of 5 t ha^{-1} rice mill waste + 4 t ha^{-1} poultry manure + 400 kg ha^{-1} NPK fertilizer in Umudike. The combined application of 150 kg ha^{-1} rate of NPK 20:10:10 fertilizer with 10 t ha^{-1} of poultry manure produced the highest amount of fresh corm yield of tannia, though not significant and was higher by 44.4 % relative to the lowest corm yield obtained under the integrated treatment of 250 kg ha^{-1} NPK fertilizer x 10 t ha^{-1} poultry manure rate (Orji *et al.*, 2017). In the same vein, Orji *et al.* (2016) reported higher total yield of *Colocasia esculenta* var. coco-india with the application of 250 kg ha^{-1} rate of NPK 20:10:10 fertilizer.

Materials and Methods

The experiment was carried out at the Forestry Research Institute of Nigeria, Eastern Research Station, Umuahia. The site lies on longitude 07º 31´ E and latitude 05º 31´ N with altitude 149 m above sea level (GPS). The annual rainfall is between 1500 and 1900 mm with temperature ranges between 27 and 30 °C. A piece of land measuring 11 x 20 m was cleared with a matchet and rubbish burnt to ash because it was virgin. The land was stumped and manually prepared into plots of beds manually. The plot size was 4 x 3 m in dimension with a space of 1.0 and 0.50 between and within plots, respectively. This experiment was laid out in a 3 x 3 factorial fitted in Randomized Complete Block Design (RCBD) in which Factor A consisted of three organic manure sources (Control, poultry and goat manures of 5 t ha^{-1} each and while Factor B formed three different plant spacings which consisted of: 1.0 x 0.30 m, 1.0 x 0.4 m and 1.0 x 0.50 m with 33333, 25000 and 20000 ha-1 plant densities, respectively. There were a total of nine treatment combinations with three replications. Cormels of tannia with accession number $NX_{S\ 001}$ with an average weight of 17.5 g were sown at three plant spacings 1.0 x 0.30 m, 1.0 x 0.40 m and 1.0 x 0.50 m with net plot areas of 1.50

m^2, 2.00 m^2 and 2.50 m^2, respectively.

All planting operations took place between 14th and 16th June of 2015, 2016 and 2017 cropping seasons. Harvesting was done in February in the succeeding years. Data were taken on the following crop attributes: Leaf area (m^2)/plant; the leaf area of tannia was accurately estimated using the mathematical relationship between linear measurements of leaves which related leaf area (y) to the product of length (L) and breath (B). The relationship was Y = K (LB) with K = 0.927 (Aquequia, 1993). The leaf area was calculated with the following model:

LA = NL x K x L x B
Where; LA = leaf Area
NL = Number of leaves/plant
K = Crop coefficient
L = Leaf length
B =Breadth of Leaf
Leaf area index (LAI): This was calculated as follows:

$$\frac{\text{Leaf area/plot}}{\text{Area of plant spacing}}$$

Harvest index: It was calculated on dry matter basis with the percent ratio of total tuber yield to total biomass above ground level according to Ahmed *et al.* (2012). At 16 weeks after planting, one crop within the net plot of each of the plots, was carefully uprooted and separated into economic (corms and cormels) and biological yields (petioles and leaves) to determine dry matter distribution. The two different plant fractions were enveloped separately and dried in an oven at a temperature of 60 °C. The dry weights were determined with a sensitive scale after one week and harvest index (HI) calculated thus:

$$HI = \frac{\text{Total tuber yield x 100}}{\text{Total tuber yield + total biomass}}$$

Assessment of Cocoyam Disease

The assessment of the incidence of cocoyam root rot blight complex (CRRBC) of tannia was on the basis of the following grade. Scoring was made to show disease

incidence on the crop in relation to treatments as described by Doungous *et al.*, (2014).
0 = no symptom, 1 = 1- 25 % severity, 2 = 26-50 % severity, 3 = 51 – 75 % severity, 4 = 76 – 100 % severity of damage of foliage with chlorosis. It was estimated with the following formula:

$$\frac{\text{Number of infected plants}}{\text{Number of assessed plants}} \times \frac{100}{1}$$

Soil analysis

Soil samples were collected prior to planting from different locations at the experimental site at the depth of 0 – 20 cm with a soil auger between 2015 and 2017 cropping seasons. The samples were properly mixed to get a composite sample from which a sub-sample was taken for laboratory analysis each year to determine the physico-chemical properties of the soil. The organic manures were also subjected to laboratory analysis to determine their nutrient composition.

Meteorological data of the experimental site

The daily weather conditions on rainfall, temperature and relative humidity of the location of the experiment were collected and recorded.

Statistical Analysis

Statistical analysis was done on the field data collected using Genstat 12 second Edition (for Windows). The data were analyzed using analysis of variance (ANOVA) techniques for a 3 x 3 factorial fitted into Randomized Complete Block Design (RCBD) according to the procedure described by Obi (2001). Fisher's Least Significant Difference (F-LSD) was used to separate significant means at 5 % probability level.

Results and Discussion

Table 1 showed that 2015 cropping season had the highest value of minimum temperature while the least and maximum values were obtained in 2016 and 2017, respectively. In the same vein, the highest total annual rainfall and relative humidity were recorded in 2017 and their least amounts were recorded in 2016 and 2015, respectively. The highest amount of sunshine (hours) and corresponding solar radiation (µm) were recorded in 2016, followed by 2015 and the least were observed in 2017. The above meteorological information was in line with the climatic requirements of cocoyam according to Uguru (2011) who reported that cocoyam required about 25 ºC of daily temperature and 2000 mm annual rainfall.

Table 1: Meteorological data of the experiment site at Umuahia, Nigeria

	Months											
Meteorological factors	**March**	**April**	**May**	**June**	**July**	**Aug.**	**Sept.**	**Oct.**	**Nov.**	**Dec.**	**Mean**	**Total**
2015												
Min. Temp (°C)	24	23	23	22	22	23	22	23	23	22.9	22.79	227.90
Max. Temp (°C)	31	29	29	28	28	30	28	30	31	29.50	29.35	293.50
Monthly Rainfall (mm)	13.0	89.7	310.9	361.2	302.7	176.3	361.6	206.1	49.70	0.00	187.12	1871.20
Relative Humidity (%)	67	70	72	74	78	68	76	66	62	35.00	66.8	668.0
Sunshine (Hours)	6.6	4.8	5.8	2.7	2.5	6.3	2.6	6.2	6.4	6.6	5.05	50.50
Solar Radiation (µm)	4.9	5.0	5.2	2.6	1.8	2.9	1.9	3.0	5.3	5.5	3.81	38.1
2016												
Min. Temp (°C)	23	22	22	20	20	21	21	20	21	23.6	21.36	213.60
Max. Temp (°C)	33	32	32	32	31	33	31	32	33	32.6	29.16	291.60
Monthly Rainfall (mm)	88.3	169.9	202.8	164.2	231.1	282.5	304.0	205.8	150.2	4.10	180.39	1803.90
Relative Humidity (%)	67.0	70.0	76.0	78.0	80.0	68	79	66.0	64.0	51.3	69.93	699.30
Sunshine (Hours)	6.5	4.9	5.9	2.8	2.6	6.2	2.7	6.3	6.5	6.8	5.12	51.2
Solar Radiation (µm)	5.0	4.8	4.6	3.2	1.6	3.8	1.8	2.8	5.2	8.5	4.13	41.3
2017												
Min. Temp (°C)	23	22	22	21	21	23	21	22	22	23	21.9	219.00
Max. Temp (°C)	32	31	30	30	29	31	29	30	31	33	30.6	306.00
Monthly Rainfall (mm)	12.2	88.8	316.8	368.0	402.6	264.1	392.4	277.0	62.0	5.6	218.95	2189.50
Relative Humidity (%)	69	70.0	71	80	80	85	82	70	65	60	73.2	732.00
Sunshine (Hours)	6.7	4.9	6.0	2.9	2.7	3.0	2.8	6.3	6.5	7.0	4.88	48.8
Solar Radiation (µm)	5.0	4.8	4.9	1.6	1.4	2.8	1.5	3.1	4.7	5.8	3.56	35.6

Source: National Root Crop Research Institute (NRCRI), Umudike Meteorological Station.

Table 2 showed that the goat and poultry manures were strongly and very strongly alkaline respectively, according to the rating of soil minerals by Ufot (2012). This means that both sources of animal manure have high capacities of neutralizing acidic soils (Ultisols). The higher content of organic matter in poultry manure than goat manure means that the former has higher potentials to enrich the soils than the latter. Also, goat manure contained higher quantities of nitrogen, phosphorous, potassium, calcium, magnesium and sulphur (primary and secondary elements) which shows that it can give better support to the growth of cereals, tubers and legumes than poultry manure.

Table 3 showed the soil physico-chemical characteristics of the soil in pre-planting soil sampling analysis for the three cropping season. According to the rating of soil nutrient indices by Ufot (2012), the texture of the site was sandy loam and moderately acidic in the period under study. The values of organic matter and available phosphorus were high throughout the periods. However, total nitrogen was low in 2015 but high in 2016, and 2017 while effective cation exchange capacity, potassium and calcium were low throughout the three years of experimentation according to Udoh and Ndon (2016). This result agrees with the result of Hota *et al*. (2014) that reported significant increase in soil total nitrogen through the application of organics along with inorganics.

Table 2: Chemical properties of organic manure

Parameters	Poultry manure	Goat manure
pH	9.40	8.60
Organic carbon (%)	43.26	17.77
Organic matter (%)	83.20	30.50
Total nitrogen (%)	0.25	0.53
Calcium (%)	3.80	4.00
Magnesium (%)	2.30	3.37
Potassium (%)	4.60	10.15
Sodium (%)	1.60	2.37
Phosphorus (%)	8.30	17.80

Source: NRCRI Soil Laboratory

Key: Rating of soil reaction and organic matter:

* Above 8.5 – 9.0 pH = strongly alkaline

* Above 9.1 pH = very strongly alkaline

*Above 2.0 % carbon of organic matter = very high

* Above 0.3 % total nitrogen = very high

Source: Ufot (2012); p. 809

Table 3: Physico-chemical properties of the experimental site before planting

Parameters	2015	2016	2017
Sand (%)	67.80	64.80	60.20
Silt (%)	11.40	11.80	12.30
Clay (%)	20.80	23.40	24.60
Texture	SL	SL	SL
pH (H_2O)	5.90	5.80	5.60
Organic carbon (%)	1.02	1.56	1.60
Organic matter (%)	1.76	2.68	2.60
Available phosphorus (cmol/kg)	39.60	68.20	60.80
Total nitrogen (%)	0.09	0.25	0.20
Exchangeable calcium (cmol/kg)	4.00	4.40	4.20
Exchangeable magnesium (cmol/kg)	1.60	1.20	1.25
Exchangeable potassium (cmol/kg)	0.12	0.19	0.20
Exchangeable sodium (cmol/kg)	0.35	0.21	0.18
Exchangeable acidity (cmol/kg)	1.12	1.20	1.18
Exchangeable CEC (cmol/kg)	7.19	7.20	7.22
Base saturation (%)	84.42	83.33	80.15

Source: NRCRI Soil Laboratory **SL = Sandy loam**

Tables 4 and 5 showed that there were no significant differences ($P > 0.05$) of main and interaction effects of spacing and animal manure sources on leaf area and leaf index within the three years of research work. Lack of significant effect was attributable to the widespread outbreak of cocoyam root rot blight complex (CRBC), which resulted in the production of less leaf canopies compared to healthy tannin leaves thereby reducing the photosynthetic efficiency of the crops. The result of this field study is contrary to the findings of Ojeniyi *et al*. (2013) and Iwuagwu *et al*. (2016) that reported significant differences on leaf area and leaf area index, respectively with application of organics. More so, there were non-significant main and interaction effects of plant spacing and manure sources on the dry matter production and harvest index of tannia across the sampling dates (Table 6) probably due to high background nutrient status of the soils. However, much more dry matter was deposited in the corms than the shoots by both main and interaction effects of spacing and manure resources at 16 WAP, though non-significant. This research report does not agree with the result of Uwah *et al.* (2011) that observed significant main effect of application rate of 15 t/ha poultry manure on shoot dry matter.

Data on Table 7 showed that there were non-significant main and interaction effects of both manure source and plant spacing on the disease incidence of tannia throughout the periods under study. The non-significant effect of manure sources and spacing on the disease incidence could be due to outbreak of cocoyam root rot blight complex that both factors conferred no advantage on diseases incidence in tannia species This result is similar to the experimental report of Orji *et al*. (2018) that recorded non-significant difference on cocoyam root rot blight complex (CRRBC) with application of various rates of poultry manure.

Table 4: Effect of manure sources, plant spacing and their interaction on the leaf area (m^2)/plant of tannia at 8, 10, 12, 14 and 16 weeks after planting (WAP)

Plant spacing(s)	2015					2016					2017				
	8	10	12	14	16	8	10	12	14	16	8	10	12	14	16
1mx0.3m	5.60	16.50	32.70	24.30	5.50	5.6	16.5	32.7	24.30	5.5	6.00	5.1	5.6	3.6	3.30
1mx0.4m	31.40	67.50	99.90	18.30	14.30	31.4	67.5	99.9	18.30	14.3	12.00	10.2	7.6	6.7	3.72
1mx0.5m	27.70	67.20	81.20	21.30	14.50	27.7	67.2	81.2	21.30	14.5	7.50	15.3	12.4	9.5	7.08
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Man(M)															
tha^{-1}															
0	19.10	37.40	54.60	17.30	8.5	19.1	37.4	54.6	17.30	8.5	5.9	8.9	5.4	3.0	2.12
GM(5)	26.80	72.10	94.30	20.00	14.20	26.8	72.1	94.3	20.00	14.2	9.4	9.6	10.6	8.0	5.52

PM(5)	18.80	41.80	64.90	26.60	11.70	18.8	41.8	64.9	26.60	11.7	10.2	12.0	9.5	8.8	6.46
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M x S															
O x 0.3	3.90	10.20	24.90	5.60	2.9	3.9	10.2	24.9	5.60	2.9	8.3	5.9	3.3	2.2	1.77
GM x 0.3	28.60	43.10	87.40	14.10	10.5	28.6	43.1	87.4	14.10	10.5	11.3	11.9	6.6	2.8	1.94
PM x 0.3	24.90	58.90	51.60	14.10	11.90	24.9	58.9	51.6	14.10	11.9	8.7	11.1	6.4	3.9	2.64
O x 0.4	9.30	18.30	35.00	10.60	7.90	3.9	28.3	35.1	10.60	7.9	6.1	3.3	6.6	3.2	2.96
GM x 0.4	42.50	28.40	50.00	27.50	21.5	42.5	118.4	50.0	27.50	21.5	16.3	13.2	9.1	8.9	4.27
PM x 0.4	28.50	69.50	97.80	21.90	13.10	28.5	69.5	97.8	21.90	13.1	8.2	19.7	16.1	11.9	9.34
O x 0.5	3.70	11.00	23.40	10.70	5.80	3.7	11.0	23.4	10.70	5.8	3.7	6.1	6.9	5.4	5.17
GM x 0.5	23.20	41.00	77.10	13.30	11.00	23.2	41.0	77.1	13.30	11.0	8.4	5.4	7.0	8.3	4.95
PM x 0.5	29.70	73.30	94.20	27.80	18.40	29.7	73.3	94.2	27.80	18.4	5.5	15.2	14.7	12.6	9.26
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5: Effect of manure sources, plant spacing and their interaction on the leaf area index of tannia at 8, 10, 12, 14 and 16 weeks after planting (WAP)

Plant spacing(S)	2015					2016					2017				
	WAP					WAP					WAP				
	8	10	12	14	16	8	10	12	14	16	8	10	12	14	16
1m x 0.3m	1.87	5.50	10.90	8.60	1.83	1.87	5.50	10.90	8.10	1.83	2.00	5.67	1.87	1.20	1.10
1m x 0.4m	7.85	16.88	24.38	4.58	3.58	7.85	16.88	24.98	4.58	3.58	3.00	2.55	1.90	1.68	0.93
1m x 0.5m	5.54	13.44	16.24	4.26	2.90	5.54	12.44	16.24	4.26	2.90	1.50	3.06	2.48	1.90	1.40
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Man(M) tha^{-1}															
0	3.82	7.48	10.92	3.46	1.70	3.82	7.48	10.92	3.46	1.70	1.68	1.78	1.08	0.60	0.42
GM	5.36	14.42	18.86	4.00	2.84	5.36	14.42	18.86	4.00	2.84	1.88	1.92	2.12	1.60	1.10
PM	3.76	8.36	12.98	5.32	2.34	3.76	8.36	12.98	5.32	2.34	2.04	2.40	1.90	1.76	1.29
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
M x S															

Plant 2015 2016 2017

O x 0.3	1.30	3.40	8.30	1.87	0.97	1.30	3.40	8.30	1.87	0.97	2.77	1.97	1.10	0.73	0.59
GM x 0.3	9.53	14.37	29.13	4.70	3.50	9.53	14.37	29.13	4.70	3.50	3.77	3.97	2.20	0.93	0.65
PM x 0.3	8.30	19.63	17.20	4.70	3.97	8.30	19.65	17.20	4.70	3.97	2.90	3.70	2.13	1.30	0.88
O x 0.4	2.33	4.50	8.75	2.65	1.98	0.98	7.08	8.78	2.65	1.98	1.53	0.83	1.65	0.80	0.74
GM x 0.4	10.63	7.10	12.50	6.88	5.38	10.63	2.96	12.50	6.88	5.38	4.08	3.30	2.28	2.23	1.07
PM x 0.4	7.13	17.38	24.45	5.48	3.28	7.13	17.38	24.15	5.48	3.28	2.05	4.93	4.03	2.97	2.34
O x 0.5	0.74	2.20	4.18	2.14	1.16	0.74	2.20	4.68	2.14	1.16	0.74	1.22	1.38	1.08	1.03
GM x 0.5	4.64	8.20	15.42	2.66	2.20	4.64	8.20	15.42	2.66	2.20	1.68	1.08	1.40	1.66	0.99
PM x 0.5	5.94	14.66	18.84	5.56	3.68	5.94	14.66	18.84	5.54	3.68	1.10	3.04	2.94	2.52	1.85
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

spacing(s)	8	10	12	14	16	8	10	12	14	16	8	10	12	14	16
0.3m x 1m	69.5	39.0	11.00	30.5	8.25	70.0	89.0	10.75	55.0	8.85	69.5	58.25	58.25	16.75	50.00
0.4m x 1m	44.5	16.75	14.00	30.5	8.25	42.5	16.75	14.0	30.75	8.75	44.5	36.00	66.75	39.00	50.00
0.5m x 1m	39.0	33.25	11.00	16.75	2.75	37.5	33.25	11.00	16.50	2.75	39.0	39.00	39.00	14.00	55.50
F-LSD	33.75	30.5	17.00	23.00	15.00	30.5	30.0	16.25	22.50	14.5	33.75	33.25	35.5	27.0	29.25
Manure(m) (tha^{-1})															
0	55.50	39.0	25.0	33.25	8.25	55.5	39.95	25.0	30.25	16.75	55.25	36.00	58.25	55.5	80.25
GM	44.50	27.75	2.75	22.25	8.25	42.5	27.75	2.75	16.75	8.25	44.5	47.25	52.75	14.00	47.25
PM	52.75	22.25	8.25	22.25	2.75	30.0	20.75	8.25	22.75	2.75	52.75	50.00	52.75	0.00	27.75
F-LSD	33.75	30.5	17.00	23.00	15.00	30.5	30.0	16.25	22.50	14.5	33.75	33.25	35.5	27.0	29.25
MXS															
0.3 x 0	83.25	66.75	33.25	58.25	16.75	83.5	60.35	30.25	50.75	16.50	83.0	58.25	66.75	33.25	66.75
0.3 x GM	33.25	8.25	33.25	33.25	8.25	32.5	30.50	58.50	30.75	8.25	33.25	8.25	66.75	91.75	91.75
0.3 x PM	50.00	41.75	8.25	8.25	0.00	60.0	41.50	8.25	16.25	8.25	50.0	41.75	41.75	41.75	83.25

0.4 x O	50.00	41.75	8.25	8.25	8.25	62.5	41.75	0.00	8.25	8.75	50.0	66.75	66.75	16.75	25.00
0.4 x GM	50.00	16.75	0.00	33.25	8.25	55.0	41.75	0.00	33.25	8.25	50.0	50.0	66.75	25.00	58.25
0.4 x PM	33.25	25.0	8.25	25.00	8.25	32.5	25.50	8.25	25.0	0.00	33.25	25.0	25.00	00.00	58.25
0.5 x O	75.00	8.25	8.75	25.00	0.00	77.5	25.0	0.00	25.0	0.00	75.0	50.0	41.75	00.00	58.25
0.5 x GM	50.00	25.0	8.25	25.00	8.25	50.0	25.0	8.25	25.0	0.00	50.0	50.0	66.75	00.00	00.00
0.5 x PM	33.25	33.25	16.75	16.75	0.00	33.0	33.5	16.75	16.25	2.75	33.25	50.00	50.00	00.00	25.00

Table 6: Effect of manure sources, plant spacing and their interaction on the dry matter production and harvest index (HI) of tannia at 16 weeks after planting (WAP)

	2015				**2016**				**2017**			
Plant spacing(S)	Corm dry matter	Shoot dry matter	Total dry matter	Harvest Index	Corm dry matter	Shoot dry matter	Total dry matter	Harvest index	Corm dry matter	Shoot dry matter	Total dry matter	Harvest index
1m x 0.3 m	104.0	8.4	112.40	0.93	100.00	8.4	108.40	0.92	113.00	10.60	123.6	0.91
1m x 0.4 m	171.0	16.7	188.00	0.91	150.00	12.7	162.70	0.92	170.00	16.70	186.7	0.91
1m x 0.5 m	140.0	17.2	157.20	0.89	135.00	10.5	145.50	0.93	140.00	17.20	157.2	0.89
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Man(M) tha^{-1}												
0	135.0	11.6	146.60	0.92	120.00	10.5	130.50	0.92	134.0	13.8	147.8	0.91
GM(5)	152.0	13.6	165.60	0.92	150.00	12.6	162.60	0.92	150.0	13.6	163.6	0.92
PM(5)	139.0	17.1	156.10	0.89	130.00	18.2	148.20	0.88	138.0	17.1	155.1	0.89
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

M x S												
O x 0.3	107.0	8.5	115.50	0.93	80.00	6.7	86.70	0.92	104.0	15.2	119.2	0.87
GM x 0.3	205.0	16.7	221.70	0.92	180.00	15.2	195.2	0.92	205.0	16.7	221.7	0.92
PM x 0.3	93.0	9.6	102.60	0.91	80.00	8.5	88.50	0.90	83.0	08.6	102.6	0.91
O x 0.4	141.0	11.1	152.10	0.93	130.00	10.8	140.80	0.92	141.0	11.10	152.1	0.93
GM x 0.4	95.0	17.3	209.30	0.92	180.50	18.4	198.40	0.91	192.0	17.30	209.3	0.92
PM x 0.4	121.0	12.4	133.40	0.91	110.00	10.1	120.10	0.92	121.0	12.40	133.4	0.91
O x 0.5	192.0	5.5	100.5	0.95	170.00	4.5	174.5	0.97	95.0	5.5	100.5	0.95
GM x 0.5	115.0	16.2	131.20	0.88	110.00	17.0	127.00	0.87	113.0	16.2	129.2	0.87
PM x 0.5	207.0	29.8	236.80	0.87	100.00	25.9	125.90	0.79	209.0	29.8	247.8	0.84
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Key: GM = Goat Manure; PM = Poultry Manure

Conclusion

It was observed that plant spacing and manure sources did not significantly influence the growth, yield, and disease assessment indices under consideration due to the outbreak of cocoyam root rot blight complex (CRRBC). So, CRRBC is a huge threat to the production of Tannia.

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