NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 50 Number 2, December 2019. Pp.112-122
Available online at: http://www.ajol.info/index.php/naj

EFFECT OF INTEGRATED PLANT NUTRIENT MANAGEMENT ON THE GROWTH AND YIELD OF TARO [*Colocasia esculenta* (L.) Schott] IN UMUDIKE, NIGERIA

Orji, K. O., Mbah, E.U., Muoneke, C.O. and Okpara, D. A.
Department of Agronomy, College of Crop and Soil Sciences, Michael Okpara University of Agriculture, Umudike, P.M.B. 7267, Umuahia, Abia State
Corresponding Authors' email: regentkaluorji@gmail.com

ABSTRACT
A field research was conducted in 2015, 2016 and 2017 seasons to investigate the effect of integrated plant nutrient management and its residues on the growth and yield of taro [Colocasia esculenta (L.) Schott] at the Forestry Research Institute of Nigeria, Eastern Research Station, Okwuta in Umuahia South Local Government Area of Abia State. The experiment was laid out in a 3 x 3 factorial fitted into randomized complete block design (RCBD) in which factor A comprised three levels of NPK 20: 10: 10 fertilizer (0, 300, 600 kg ha-1 while factor B consisted of three levels of poultry manure (0, 5, 10 t ha-1). There were a total of nine treatment combinations with three replicates. Cormels of equal sizes were planted in June in each of the three years and harvested in February of the following year. The results showed that integrated plant nutrient management and its residual effects did not differ significantly (P≥0.05) on plant height and stem girth but, significantly influenced (P≤0.05) the number of leaves/plant at 14 and 16 weeks after planting (WAP) in 2017 by application of NPK fertilizer rates. Also, main effect of NPK fertilizer rates and their interactions with poultry manure rates significantly increased (P≤0.05) the number of suckers/plant at 16 WAP. The main effects of NPK fertilizer rates of 300 and 600 kg ha-1 applications differed significantly (P≤0.05) on the corm girth, corm yield, cormels yield, average cormels yield and total yield in 2017.Therefore, this study recommends the application of 600 kg ha-1 NPK 20:10:10 fertilizer or a combination of 600 kg and 5 t ha-1 poultry manure for production of taro in sandy loam soil of Umudike.

Keywords: Coco-india, cormels, residues, factorial, and rates

Introduction

Taro [*Colocasia esculenta* (L.) Schott] is a monocotyledonous and herbaceous crop that originated from South East Asia. It is a crop plant that tolerates shade as a C3 plant. *Taro* and *Tannia* are commonly called cocoyams in many parts of the world especially in Africa. In the Pacific regions both genera are known as *taro* (Buke and Gidago, 2016). In Nigeria, twelve cultivars of taro species among which include; NCe 001 (*CocoIndia*), NCe 002 (*Ede ofe*, green), NCe 003 (*Ede ofe*, purple), NCe 004 (*Ede ofe*, giant), NCe 005 (*Nkpong*), NCe 006 (Ghana), NCe 007 (*Ibococo*, green), NCe 008 (*Ibococo*, pink), NCe 009 (*Ede Orba*), NCe 0010 (Akiri), NCe 0011 (*Akpahuri*), and NCe 0012 (*Akiri mgbawa*) have been identified from germplasm collections at National Root Crop Research Institute (NRCRI), Umudike for cultivation. No new improved genotypes have been developed in Nigeria mainly due to difficulties associated with conventional breeding methods (NRCRI, 2009 and 2010). Taro has been reported to have a wide range of uses in religious festivals, as mild laxatives, in treatment of wounds and snake bites. It reduces body temperature in a feverish patient and others (Buke and Gidago, 2016).

Nutritionally, it contains more than twice the carbohydrate content of potato and a good source of magnesium, vitamin C, iron and potassium (Buke and Gidago, 2016). Taro starch is also good for peptic ulcer patients, patients with pancreatic disease, chronic liver problems, inflammatory bowel disease and gall bladder disease (Emmanuel-Ikpeme *et al.*, 2007). Its major constraints include diseases like taro leaf blight, dasheen mosaic virus, and bacterial leaf necrosis. Others are ignorance of different food forms, poor information on soil nutrient requirements and poor knowledge of its contributions to health, household and national economy. Integrated plant nutrient management involves a combination of both organic matter and /or synthetic/chemical fertilizers of plant nutrients required to increase crop growth and yield which is appropriate to each cropping system and situation and at same time achieve sustainable soil fertility and productivity. It seeks to facilitate early release of nutrients to crops without causing harm to the soil environment unlike pure inorganics. The application of integrated plant nutrient management is not yet common to resource poor farmers due to the difficulties associated with calculations of formula for appropriate soil nutrient requirements. However, Hamma *et al.* (2014) reported significant increase in growth and yield of taro by combined application of 10 t ha^{-1} poultry manure and 150 kg ha^{-1} NPK fertilizer. Field studies have also shown significant effects on growth and yield of taro by application of integrated organics and inorganics (Chukwu and Eteng, 2014; Nwite *et al.,* 2016; Iwuagwu *et al.,* 2016). Currently, there is a dearth of information on residual effects of integrated plant nutrient management on taro production which may be attributed to its tuberous nature as a deep- feeding crop. Nevertheless, succeeding crop of safflower grown without application of organic manures and inorganic manures during spring season significantly produced higher seed yield in organic farming compared to inorganic farming in groundnut – safflower sequence cropping system (Malligawad, 2010). Hence, this study aims at investigating the integrated plant nutrient management and its residual effects on the growth and yield of taro (*Colocasia esculenta*) in Umudike, Southeast Nigeria.

Materials and Methods

Field studies were carried out in 2015, 2016 and 2017 cropping seasons at the Forestry Research Institute of Nigeria, Eastern Research Station, Okwuta, Umuahia in Abia State. The research farm lies on longitude 07° 31´ E and latitude 05° 31´ N with an elevation of 145 m above sea level (GPS). A piece of land with a dimension of 11 x 20 m was cleared with a machete. The land was prepared into plots of beds manually with an Indian hoe. Each plot size measured 4x3m in dimension with a net plot of 2.5 m^2. The space between and within two plots was 1.0m and 0.50m, respectively. Taro (*Colocasia esculenta* var. *Ede ofe,* purple) with accession number NCe 003 used in this experiment was bought at Orba market in Nsukka Local Government Area of Enugu State. Cormels of equal size (an average weight of 17.5g) were planted at 0.50 x 1.0m. All planting operations took place between 14th and 16th June of each farming season and harvesting was done in February the following year.

This experiment was laid out in a 3 x 3 factorial fitted in randomized complete block design (RCBD) in which poultry manure formed factor A with three levels - 0, 5, 10 t ha^{-1}, while factor B consisted of three levels - 0, 300, 600 kg ha^{-1}. There were a total of nine treatment combinations in three replicates. These treatments were applied in 2015 and repeated in 2017 while residual effect of the soil amendments observed in 2016 with the same *taro*. The treatments were applied through the method of band placement at 8 weeks after planting (WAP) and after earthen up. Weeding was done at four weeks intervals. The following parameters were taken: plant height, plant girth, number of leaves/plant, number of suckers/plant at 8, 10, 12, 14, and 16 WAP and yield and yield components.

Soil samples were collected prior to planting from different locations at the experimental site at the depth of 0- 20cm with a soil auger in 2015, 2016 and 2017 cropping seasons. The samples were properly mixed to get a composite sample from which a sub-sample was taken for laboratory analysis to determine the physico-chemical characteristics of the soil. The daily weather conditions on rainfall, temperature, sunshine, solar radiation and relative humidity of the location of the experiment were collected and recorded. The field data collected was subjected to analysis of variance (ANOVA) techniques following Obi (2001). Fisher`s Least Significant Difference was applied to detect significant difference between two means after mean separation at 5 % probability level.

Results and Discussion

Table 1 shows that 2015 cropping season had the highest value of minimum temperature while the least and maximum values were obtained in 2016 and 2017, respectively. The highest total annual rainfall and relative humidity were recorded in 2017 and their least amounts recorded in 2016 and 2015 each. 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 requires about 25ºC of temperature and 2000mm annual rainfall. Table 2 shows the physico-chemical characteristics of the pre-planting soil sample analysis for the three cropping seasons. 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 period.

Total nitrogen was low in 2015 but high in 2016, and 2017, while exchangeable cation exchange capacity, potassium and calcium were low throughout the three years of experimentation according to Udoh and Ndon (2016). These results agree with the results of Hota *et al*. (2014) who reported a significant increase in soil total nitrogen with a combined application of organic manure and inorganic fertilizer. In 2015 and 2017 cropping seasons, application of NPK fertilizers, poultry manure and their interactions and their residual effects observed in 2016 did not significantly ($P \geq 0.05$) increase plant height and girth across the period of data collection (Tables 3 and 4). The lack of significant effect of fertilizer or poultry manure or both on plant height and girth may be due partly to the high rainfalls of over 2000mm which caused erosion and leaching of nutrients on the sandy loam soil or partly due to the soil N of 0.09 – 0.25% which did not affect plant growth following the application of fertilizer or manure. Fairhurst (2012) reported critical soil N of 0.15%. Results on Table 5 show that main effect of NPK fertilizer and poultry manure rates and their interactions/residues did not significantly ($p \geq 0.05$) increase the number of leaves/plant across the intervals of data taken in 2015 and 2016 except at 14 and 16 WAP in 2017. The non-significant effect of integrated plant nutrient management and its residues on this trait was attributed to the widespread outbreak of taro leaf blight (TLB) in the net plots resulting in leaf defoliation and die back which made the crop plants appear like candle sticks (Plates 1 and 2). Generally, 2016 residual effect of NPK fertilizer compared to poultry manure produced less number of leaves/plant than the previous year which was attributed to poor effect of NPK fertilizer residues arising from its rapid mineralization and lost through leaching.

In 2017, it was observed that the number of leaves/plant increased with increase in the rates of NPK fertilizer application, although it did not significantly increase the trait at 8, 10 and 12 WAP, but significantly influenced ($P \leq 0.05$) it at 14 and 16 WAP with the application rate of 600 kg ha^{-1} NPK fertilizer (Table 5). The significant effect of NPK fertilizer at 14 and 16 WAP was traceable to regeneration of suckers because taro leaf blight is considered a monocyclic disease. Main effect of NPK fertilizer rates did not differ significantly ($P \geq 0.05$) on the number of suckers/plant at 8, 10, 12 and 14 WAP, but significantly ($p \leq 0.05$) increased the trait at 16 WAP in 2015 cropping season by the application of 300 $kgha^{-1}$ dose (Table 6). The significant effects of NPK fertilizer at 16 WAP could be as a result of the availability of photosynthetically active radiation (PAR) which played a fundamental role in physiological processes such as photosynthesis and photomorphogenesis in plants. This result is in line with the research report of Orji and Ogbonna (2015) and Ogbonna and Nweze (2012) who observed significant increase in the number of suckers/plant by the application of 200 kg ha^{-1} rate of NPK 15:15:15 fertilizer. In 2016, main effect of NPK fertilizer residue could not cause significant increase ($p \geq 0.05$) on the trait. The maximum value was recorded at 16 WAP by the application of 600 kg ha^{-1} NPK fertilizer whereas the least number was observed at 8 WAP from the control. Generally, the number of suckers/plant increased with incremental application of treatments across the periods of data collection (Table 6). In 2017, main effect of NPK fertilizer rates of 300 and 600 kg ha^{-1} did not significantly influence ($p \geq 0.05$) the crops attribute at 8, 10 and 12 WAP. However, significant effects ($p \leq 0.05$) were recorded at 14 and 16WAP by the application of 600 kg ha^{-1} and 300 kg ha^{-1} NPK fertilizer rates. This could be attributed to the quick mineralization of NPK and availability of photosynthetically active radiation needed to trigger photosynthesis and photomorphogenesis from which starch is produced for cell differentiation, and expansion and translocation of the starch to the corm for cormel formation.

Main effect of poultry manure rates did not significantly influence ($p \geq 0.05$) the number of suckers/plant across the period under investigation. In 2016, the poultry manure residual effect did not differ significantly on the number of suckers/plant which was attributed to uniform production in the number of suckers/plant arising from low residual effect of poultry manure which could not meet the nutrient requirement of taro as a heavy feeder.

There was no significant interaction ($p \geq 0.05$) between NPK fertilizer and poultry manure rates on the number of suckers/plant in 2015. In 2016 cropping season, the residues of NPK fertilizer and poultry manure rates did not significantly influence the number of suckers/plant. In 2017, the interaction between NPK fertilizer and poultry manure rates did not significantly affect ($p \geq 0.05$) the number of suckers/plant at 8, 10, 12 and 14 WAP but significantly increased at 16 WAP by the application of different treatment combination sources. The highest number of suckers/plant was produced by the combined application of 600 kg ha^{-1} fertilizer and 5 t ha^{-1} poultry manure while, the least number of suckers/plant was produced by the control. The most significant effect of 600 kg ha^{-1} NPK fertilizer x 5 t ha^{-1} PM interaction at 16 WAP on the number of suckers/plant might be due to nutrient synergy formed between NPK fertilizer and poultry manure which created a nutrient balance ratio for the absorption of nitrogen and potassium by taro for growth and cormelization Table 6). In 2015, the main effect of NPK fertilizer rates significantly increased ($p \leq 0.05$) corm girth (27.56cm) when 600 kg ha^{-1} rate was applied compared to the control (Table 7). The significance could be traceable to the ability of the soil to meet the nutrient requirement with 600 kg ha-1 NPK fertilizer when other growth factors were available despite outbreak of taro leaf blight at 10 WAP.

In 2016, the residual effect of NPK fertilizer rates did not significantly increase ($p \geq 0.05$) the corm yield and yield components of taro. In 2017, there were significant differences ($p \leq 0.05$) in NPK fertilizer rates on the corm yield and total yields except number of cormels/plant. The significant effect of NPK fertilizer on these yield parameters could be attributed to the holistic and comprehensive nature of NPK 20:10:10 fertilizer that might have met the nutrient requirements of taro due to its high content and provision of nitrogen, for vegetative growth and photosynthesis and translocation of photosynthates from the source to the sink (corms and cormels). This result is in agreement with the findings of Shabbier (2007) who reported that NPK fertilizers are an all-in-one source of plant nutrients for the individual crops and soils. Imran *et al.* (2010) also reported significant increase in the yield and yield components of taro by application of different sources of manure and fertilizers, while Orji *et al.* (2016) also reported higher total yield of *Colocasia esculenta* (var. *coco-india*) with application of 250 kg ha^{-1} rate of NPK 20:10:10 fertilizer. Uwah *et al.* (2011) reported that each incremental rate of potassium fertilizer increased corm and cormel weight only up to the 80 kg ha^{-1} rate. In this study, increasing the NPK fertilizer rate up to 300 kg ha^{-1} increased corm and total yields significantly with no fertilizer application, but beyond 300 kg ha-1 NPK fertilizer rate, no further yield improvements occurred.

Cormel yield increased with incremental application of NPK fertilizer up to 600 kg ha $^{-1}$. Cormel yield obtained from application of 600 kg ha^{-1} NPK fertilizer was greater than the yield values from 300 kg ha $^{-1}$ NPK fertilizer by 53.1 % and greater than the control by 281.0 %. Main effect of poultry manure rates and their residual effects did not significantly increase corm yield and yield components in 2015, 2016 and 2017 each. The non-significant effect of poultry manure might be attributed to taro leaf blight and luxurious consumption of poultry manure by taro. This finding agrees with the result of Cox and Kasiamani (1998) who reported that taro leaf blight (TLB) disease caused by *phytophthora colocasia* could cause up to 50% loss in corm yield. There were no significant interactions ($p \geq 0.05$) between NPK fertilizer and poultry manure rates on the yield traits in 2015 and 2017 cropping seasons (Table 7). In 2016, there was no significant difference ($p \geq 0.05$) in poultry manure residues on the same traits.

Conclusion

Results of the study have shown that integrated plant nutrient management and its residues significantly improved the number of leaves and suckers of taro, but were statistically same in yield in 2015 and 2016 cropping seasons. However, they significantly increased yield and yield components of taro in 2017cropping season.Therefore, we recommend to farmers to adopt the application of 600 kg ha^{-1} NPK 20:10:10 fertilizer or a combined application of 600 kg ha^{-1} fertilizer and 5 t ha^{-1} poultry manure for production of taro in the sandy loam of Umudike.

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Plate 1: taro var. edeofe purple (NCe 003)

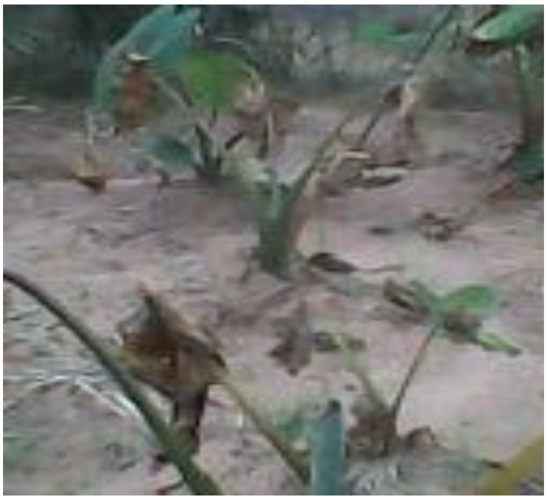

Plate 2: Taro infected with TLB

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

Meteorological factors	Months										
	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: 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

Table 3: Effect of poultry manure, NPK fertilizer and their interaction on plant height of taro (cm) at 8, 10, 12, 14 and 16 weeks after planting (WAP) in 2015, 2016 and 2017 cropping seasons

NPK fertilizer rates (Kg ha^{-1})	2015 WAP					2016 WAP					2017 WAP				
	8	10	12	14	16	8	10	12	14	16	8	10	12	14	16
0	46.20	62.40	72.6	82.3	78.5	49.3	56.4	54.5	51.4	50.1	30.4	32.4	39.0	43.6	44.0
300	51.00	67.10	80.3	83.3	84.7	50.9	57.0	54.6	51.7	53.4	34.2	39.9	83.0	58.0	60.0
600	54.40	69.00	86.2	87.8	85.7	50.9	56.5	56.1	52.7	54.1	42.1	46.2	55.0	65.8	64.0
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rates of PM (tha^{-1})															
0	47.80	63.4	77.30	77.7	76.7	48.2	59.4	51.0	48.1	48.8	35.2	42.4	49.0	54.2	50.8
5	50.10	69.8	80.60	86.8	81.2	52.0	55.0	55.5	53.6	52.0	39.2	54.0	82.0	57.6	54.3
10	53.70	65.3	81.30	88.9	90.8	50.9	55.6	58.8	54.1	56.9	40.1	52.8	60.0	55.7	53.5
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x PM															
0 x 0	52.20	67.8	83.6	68.8	67.3	45.1	52.4	48.8	48.7	54.0	27.9	31.7	33.0	34.3	30.2
0 x 5	56.10	71.5	85.4	88.5	76.5	46.6	59.9	56.2	47.5	56.7	32.7	32.3	40.0	44.9	41.5
0 x 10	54.90	68.7	89.9	92.7	91.7	52.5	57.1	52.04	50.0	59.1	30.5	33.2	46.0	51.8	50.6
300 x 0	45.60	62.7	65.0	72.7	73.8	49.6	58.5	60.00	56.9	54.5	39.2	48.0	59.0	63.0	60.0
300 x 5	56.30	72.7	77.7	85.2	83.2	50.2	51.8	51.0	47.6	47.2	32.7	35.5	44.0	56.2	51.0
300 x 10	51.20	66.0	75.2	88.9	97.0	53.8	60.7	55.2	53.7	53.2	30.7	36.3	46.0	54.8	50.7
600 x 0	44.30	56.5	83.2	91.5	89.1	50.1	62.5	62.2	56.8	62.2	38.6	47.6	55.0	65.0	62.0
600 x 5	48.80	65.8	78.7	86.7	84.1	55.9	53.4	53.2	49.2	52.5	52.3	55.0	60.0	71.8	70.6
600 x 10	45.70	65.6	78.8	85.2	83.8	53.8	53.7	58.8	57.2	53.6	32.5	36.0	50.0	60.5	58.9
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Effect of poultry manure, NPK fertilizer and their interaction on plant girth (cm) of taro at 8, 10, 12, 14 and 16 weeks after planting (WAP)

NPK fertilizer rates (Kg ha^{-1})			2015 WAP					2016 WAP					2017 WAP		
	8	10	12	14	16	8	10	12	14	16	8	10	12	14	16
0	9.42	18.78	19.31	19.00	19.86	13.14	12.36	12.90	11.67	10.49	10.04	11.39	13.22	13.42	11.00
300	11.23	20.03	21.19	19.78	19.97	13.15	14.84	14.08	11.97	10.96	10.86	13.19	15.88	16.25	17.0
600	12.31	20.00	20.81	20.00	20.47	13.18	18.86	13.64	13.00	11.14	11.97	15.33	17.67	17.49	17.0
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Rates of PM (t ha^{-1})															
0	10.28	18.50	20.11	18.53	18.22	12.9	14.17	13.49	11.78	9.83	9.36	12.17	15.13	14.86	14.00
5	12.01	20.83	21.31	19.72	19.22	13.14	14.20	14.53	12.42	10.69	12.21	13.58	16.03	16.78	15.00
10	10.67	19.47	20.89	20.53	20.58	13.38	15.71	14.61	12.44	12.06	11.31	14.17	15.61	15.51	17.00
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x PM															
0 x 0	11.25	18.42	20.92	16.83	18.67	9.5	15.00	13.00	10.83	11.58	9.42	10.58	10.92	9.92	08.00
0 x 5	14.00	21.83	21.08	19.75	19.50	11.33	16.88	14.54	11.25	13.25	11.47	11.25	13.00	15.50	12.00
0 x 10	11.67	19.75	21.58	20.42	21.42	11.83	16.63	14.67	11.85	13.67	9.25	12.33	15.75	14.83	13.00
300 x 0	11.83	20.08	17.58	17.83	19.00	12.83	15.22	13.75	12.25	12.21	11.58	16.17	18.17	17.25	15.00
300 x 5	11.03	20.50	19.33	19.83	19.08	13.33	14.17	14.08	11.58	9.58	11.25	11.67	15.08	16.08	14.00
300 x 10	11.83	19.50	21.00	21.67	21.83	13.34	15.13	15.50	12.92	11.17	9.75	11.75	14.38	15.42	16.00
600 x 0	9.75	17.00	21.83	20.92	19.17	14.79	16.92	15.60	12.83	12.37	12.92	15.75	15.25	17.42	17.00
600 x 5	11.00	20.17	20.50	19.58	17.80	14.75	14.46	16.75	12.17	10.67	13.92	17.83	20.00	18.75	17.00
600 x 10	9.50	19.17	20.08	19.50	18.50	13.71	16.79	17.78	14.25	11.25	9.08	12.42	17.75	16.29	16.00
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5: Effect of poultry manure, NPK fertilizer and their interaction on the number of leaves/plant of taro at 8, 10, 12, 14 and 16 weeks after planting (WAP)

NPK fertilizer rates (Kg ha^{-1})	2015 WAP					2016 WAP					2017 WAP				
	8	10	12	14	16	8	10	12	14	16	8	10	12	14	16
0	11.61	19.83	17.17	17.39	18.69	7.03	8.83	11.60	13.06	14.78	3.89	5.67	8.36	9.33	10.86
300	11.44	20.39	17.83	18.72	20.81	7.28	8.92	12.64	13.25	15.47	4.61	7.39	11.22	**13.25**	**16.89**
600	12.03	20.33	18.69	21.92	21.92	7.44	9.31	13.22	13.69	15.50	4.28	7.89	11.44	**15.75**	**19.46**
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	3.88	3.57
Rates of PM (t ha^{-1})															
0	11.36	19.53	16.67	18.14	20.0	6.56	8.22	11.39	12.94	14.69	3.75	6.00	9.42	11.97	13.82
5	12.06	19.50	18.42	20.14	20.31	7.36	9.00	11.89	13.50	15.36	4.81	7.69	10.94	13.61	16.72
10	11.67	21.53	18.61	19.75	21.11	7.83	9.81	12.33	13.56	15.69	4.22	7.25	10.67	12.75	16.67
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x PM															
0 x 0	11.33	18.33	17.00	16.59	11.50	6.08	7.33	10.58	12.50	13.08	3.67	4.50	5.33	5.75	5.67
0 x 5	11.92	19.00	18.25	17.42	20.92	6.50	7.83	11.00	13.08	14.08	4.17	6.50	8.58	10.50	12.33
0 x 10	12.83	22.17	19.25	22.17	23.00	7.58	8.75	10.92	13.58	14.33	4.06	6.00	11.17	11.75	14.58
300 x 0	10.25	18.34	16.33	17.67	17.17	6.92	10.17	11.08	13.08	16.17	4.58	8.83	13.25	13.42	17.17
300 x 5	12.92	20.58	16.83	17.08	19.00	6.42	8.67	11.33	12.92	14.25	5.17	6.17	9.25	12.25	14.25
300 x 10	11.17	22.25	20.33	17.42	19.92	7.75	8.67	12.00	13.17	14.58	4.08	7.17	10.67	14.08	19.25
600 x 0	12.50	21.25	21.92	20.17	23.42	8.67	10.50	13.33	15.08	17.83	4.42	8.42	9.67	16.75	18.62
600 x 5	11.33	19.58	17.92	25.92	25.25	7.17	8.67	11.83	13.83	15.75	5.08	10.42	14.50	18.08	23.58
600 x 10	11.00	20.17	16.25	19.67	17.08	8.17	10.67	14.42	14.75	17.17	3.33	4.83	10.17	12.42	16.17
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6: Effect of poultry manure, NPK fertilizer and their interaction on the number of suckers/plant of taro at 8, 10, 12, 14 and 16 weeks after planting (WAP)

NPK fertilizer rates (Kg ha^{-1})	**2015 WAP**					**2016 WAP**					**2017 WAP**				
	8	10	12	14	16	8	10	12	14	16	8	10	12	14	16
0	2.97	6.58	8.56	9.00	9.75	1.66	2.92	4.56	4.58	5.86	0.44	0.97	2.44	3.58	3.81
300	3.06	7.17	9.31	10.53	**12.5**	1.67	3.50	4.75	5.08	6.06	0.50	1.58	5.31	4.64	**7.08**
600	3.50	6.89	9.14	10.64	11.31	1.83	3.53	5.33	5.31	6.08	0.56	1.72	4.11	**6.75**	**8.53**
F-LSD(0.05)	NS	NS	NS	NS	2.08	NS	NS	NS	NS	NS	NS	NS	NS	2.23	1.90
Rates of PM (t ha^{-1})															
0	2.89	6.50	8.39	9.06	10.53	1.47	2.94	4.81	4.92	5.86	0.44	1.06	3.08	4.75	5.72
5	3.17	6.89	9.33	10.78	11.83	1.89	3.44	4.86	5.22	5.94	0.58	1.75	5.11	5.25	6.89
10	3.47	7.25	9.28	10.33	11.19	1.89	3.56	4.96	5.25	6.17	0.44	1.47	3.67	4.97	6.81
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x PM															
0 x 0	3.00	6.25	7.92	8.25	10.67	1.00	2.08	4.50	4.50	4.92	0.42	0.83	1.58	2.50	1.50
0 x 5	3.50	7.00	8.17	10.25	13.58	1.50	3.17	4.90	4.58	5.83	0.50	1.08	2.25	3.75	4.50
0 x 10	4.00	7.42	11.83	13.08	13.25	1.42	2.83	4.85	4.83	5.50	0.58	1.00	3.50	4.50	**5.42**
300 x 0	2.92	6.92	9.83	9.58	11.08	1.58	3.67	5.08	5.25	6.17	0.58	2.00	4.42	5.08	**7.33**
300 x 5	3.00	7.08	7.75	9.17	8.5	1.25	2.92	4.67	4.83	5.83	0.25	1.33	7.83	4.42	**5.50**
300 x 10	3.25	7.50	8.08	8.25	9.67	1.83	3.00	4.58	5.42	5.58	0.50	1.43	3.67	4.42	**8.42**
600 x 0	2.75	6.33	10.25	9.33	10.83	1.68	3.83	5.33	5.67	6.75	0.42	1.58	3.25	6.67	**8.33**
600 x 5	3.00	6.58	9.25	12.92	12.42	2.17	3.83	5.42	5.33	5.92	1.00	2.83	5.25	7.58	**10.67**
600 x 10	3.17	6.83	7.92	9.67	10.67	2.17	4.50	6.08	5.75	7.42	0.25	0.75	3.83	6.00	**6.58**
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	3.28

Table 7: Effect of poultry manure, NPK fertilizer and their interaction on the yield (Kgha^{-1}) and yield components of taro at harvest

	2015						2016						2017					
NPK fertilizer Rates (Kg ha^{-1})	**Corm girth(cm)**	**Corm yield**	**No of Cormels/plant**	**Cormels' yield**	**AV. Cormels' yield**	**Total yield**	**Corm girth**	**Corm yield**	**No of cormels/plant**	**Cormels' yield**	**AV. Cormels' yield**	**Total yield**	**Corm girth/**	**Corm yield**	**No of cormels/plant**	**Cormels' yield**	**AV. Cormels' yield**	**Total yield**
0	24.44	236	15.2	376	27.9	632	20.47	128	5.72	172	29.3	299	18.75	105.3	5.44	75.6	18.3	172.0
300	26.42	251	16.2	492	28.1	743	20.39	146	5.81	181	30.1	315	21.56	152.8	7.58	**188.0**	**24.9**	**347.0**
600	**27.56**	336	23.6	521	29.6	775	21.03	180	6.22	186	32.1	326	**23.17**	**192.1**	8.89	**288**	**24.8**	**413.0**
F-LSD(0.05)	2.23	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2.74	49.46	NS	83.8	8.08	125
Man(M) t ha^{-1}																		
0	27.06	231	15.2	450	27.8	681	20.53	135	4.97	156	27.4	293	20.47	149.3	8.36	133	21.6	321
5	25.89	268	22.4	461	28.1	714	20.44	148	5.69	192	31.8	322	21.39	131.9	5.81	173	23.4	265
10	25.47	324	17.4	478	29.8	756	20.92	172	7.08	192	32.2	326	21.61	169.0	7.75	185	23.0	346
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x M																		
0 x 0	28.83	201	17.5	351	25.2	552	19.50	122	4.5	138	29.8	263	16.67	62.5	7.67	23	12.1	85
0 x 5	26.75	219	31.8	360	26.8	563	19.67	128	6.58	181	26.8	306	17.92	107.6	2.92	51	19.2	158
0 x 10	26.75	240	20.5	410	26.6	649	20.42	125	4.67	145	30.9	250	21.67	145.8	5.75	153	23.8	274
300 x 0	24.25	296	12.9	500	29.7	762	20.92	127	6.17	204	30.1	326	21.92	135.4	8.25	205	22.3	358
300 x 5	25.67	229	16.8	479	29.8	726	20.42	133	7.33	181	26.5	309	21.42	128.5	5.83	165	29.2	293
300 x 10	23.33	276	15.9	441	27.9	781	20.58	132	4.92	160	31.6	285	21.33	194.4	8.67	194	23.1	389
600 x 0	28.06	496	15.3	531	33.3	827	21.17	156	6.42	233	35.6	389	22.83	250	9.17	292	30.4	521
600 x 5	25.25	247	18.8	535	28.9	753	21.25	253	7.33	216	29.1	349	24.83	159.7	8.67	184	21.9	544
600 x 10	26.33	287	15.7	583	29.4	837	21.75	188	5.33	163	34.1	344	21.83	166.7	8.83	2.08	22.10	375
F-LSD(0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS