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Effect of Fertilizer Application and Interplanted Cassava on Growth and Yield of Plantain in Oil Palm Based System

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Abstract

Due to the slow growth and long gestation period of oil palm farmers are often faced with challenges of weed control before oil palm canopy closure hence the need to introduce plantain as component crop with the oil palm. A two years trial was conducted in in Ovia North East LGA, Edo State, Nigeria (Latitude 6.636oN, 6.909^{o}N and Longitude 6.182^{o}E, 6.364^{o}E) to evaluate the effect of NPKMg fertilizer and interplanted cassava on growth and yield of plantain in oil palm based system. The treatment consisted of NPKMg fertilizer as the main block treatment (with and without NPKMg fertilizer) and crop combinations [oil palm/plantain (OPP) and oil palm/plantain/cassava (OPPC)] as sub block treatments. The treatments were laid out in split block arrangement in RCBD replicated thrice. Data were collected on plantain plant height, number of leaves/pseudostem, leaf area index, number of suckers/pseudostem, number of days to 50% flowering of main psuedostem and first ratoon plants, number of days to first appearance of peeper sucker from main pseudostem, number of leaves at flowering from main pseudostem and first ratoon plants, finger weight (kg/bunch), finger circumference/finger (cm), finger length/finger (cm), number of fingers/bunch, biomass weight (t/ha), number of bunches/ha and bunch yield (t/ha). NPKMg fertilizer significantly increased ($p<0.05$) the growth and number of sucker produced. Plantain planted in OPP combination had taller plant and more number of suckers (first ratoon plant and second ratoon plant, respectively) relative to those in OPPC combination while plantain planted in OPPC combination lead to delayed appearance of peeper suckers, delayed fruiting of plantain and resulted to 18, 15.8, 1.6, 6, 8.3 and 12 % increase ($p<0.05$) in plantain bunch weight, finger weight, finger circumference, finger length, number of fingers and biomass weight, respectively relative to those in oil palm/plantain (OPP) combination.

Keywords: Oil palm; Cassava; Plantain; Fertilizer; Bunch; Tuber.

1. Introduction

In south southern Nigeria, food crop such as cassava, pepper and cocoyam are mainly interplanted with oil palm due to its slow growth; wide inter row spacing, long gestation period high initial cost of investment and maximum land usage must therefore be based on the exploitation of interplanting. Interplanting of oil palm with semi-permanent crop will help facilitate the maintenance of the plantation, within the first four years when the canopy of the oil palm had not closed up. Okpala – Jose *et al.* (1996), reported little interception of light by the oil palm within the first few years of its growth. Analysis of the soil sample showed slight decreased in soil nutrient status in plots of sole and interplanted oil palm within the first four years of oil palm establishment (Diemier *et al.*, 2004).

Plantain and cassava have numerous uses among which are, adaptability to wide range of ecological zones and soils, relatively easy to cultivate, high economic returns and flexibility in time of planting and harvesting. They are generally accepted and affordable by both the rich and the poor in southern Nigeria. They provide food all year round and can survive extended period of drought. Both crops can thrive under wide range of soil (the poorest soil

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with low nutrient), they provide permanent stay in the oil palm inter row, thereby reduce the frequent disturbance of oil palm root from continuous tillage, land preparation and cultivation.

The primary nutrients such as NPK are readily depleted from the soil and become limiting in soils under oil palm (Robert, 2004) and if not replenished can reduce yield of the oil palm and component crops. Most of the component crops on their own are heavy feeders while some like cassava has the advantage of providing a good ground cover for the component crop and this enhances soil temperature, soil water status and plant growth (Agrobrief, 2011). Provision of the limiting soil nutrients through fertilizer application might reduce any possible competition that may arise in the interplanting system. This present study was therefore carried out to obtain the information needed to develop effective strategies for interplanted cassava/plantain in oil palm based system.

2. Materials and Method

2.1. Experimental Site and Cropping History

An experiment was conducted at Obazuwa village in Ovia North East LGA, Edo State Nigeria (Latitude 6.636^{o}N, 6.909^{o}N and Longitude 6.182^{o}E, 6.364^{o}E) from 2016 – 2018. Edo state is located in the rain-forest agro-ecological zone of south- southern Nigeria with an annual rainfall ranging from 1500 mm to 2135 mm. The minimum and maximum temperature ranges are between 15-25 and 25-35 °C, respectively. The soil of the experimental site is sandy with 91, 1.8 and 7.2 % sand, silt and clay respectively, and pH of 6.3.

2.2. Treatment and Field Management

The treatments were laid out in split block arrangement in RCBD replicated thrice. Oil palm, plantain and cassava were planted in the first year (2016) and cassava was replanted in second year (2017). NPKMg fertilizer (with and without fertilizer), with fertilizer (NPKMg 12:12:17:2 at recommended rate for each crop). Oil palm received 18.8 kg/ha (6 months after transplanting) and 37.6 kg/ha (1st year after transplanting) of NPKMg (12:12:17:2), Cassava plant planted in 2016 and 2017 received 88.2 kg/ha NPKMg (12:12:17:2), respectively. Plantain main pseudostem and first ratoon plant received 100 kg/ha NPKMg (12:12:17:2), respectively. Split application was done for plantain at 4 months after planting (vegetative) and 8 months after planting (flowering). Crop combination include: oil palm/plantain, oil palm/cassava/plantain. NPKMg fertilizer applied to OPP and OPPC were 118.8 and 207 kg/h, respectively in 2016/2017 cropping season while in 2017/2018 cropping season, 137.6 and 225.8 kg/ha NPKMg were applied, respectively.

2.3. Oil Palm Establishment

Oil palm seedlings (Tenera variety), were planted out in 7.5 m triangular pattern (Bonneau *et al*., 2014), giving 205 stands/ ha and each seedlings were protected against rodent attack by a wire mesh stuck 30.5 cm from the seedlings.

2.4. Cassava and Plantain Establishment

Plantain maiden suckers (Giant horn plantain specie "*Ogede-agba"*) were established alongside with cassava. Plantain sword suckers were planted at spacing of 3.0 m x 2.0 m, cassava plant was 1 m x 1 m. In crop combinations of oil palm/plantain, a constant arrangement of one row of oil palm bordering two rows of plantain plants with distance of 2.25 m from oil palm and 2 m between plantain plants inter row with 3 m intra row. In crop combinations of oil palm/plantain/cassava, a constant arrangement of one row of oil palm bordering three rows of cassava plants and two row of plantain plants. The distance of oil palm from cassava plants is 1.25 m and oil palm from plantain plants is 2.25 m, 2 m between plantain inter-row and 3 m between plantain intra row. 1 m between cassava inter-row and 1 m between cassava intra row

2.5. Data Collection

The following data were collected on eight plantain plants per plot on monthly basis starting from 3 MAP -14 MAP for main pseudostem, 15-20 MAP for first ratoon plants and 21-24 MAP for the second ratoon plants during 2016/2017 and 2017/2018 cropping season.

Growth: Plant height (m), number of leaves per plant, number of suckers per plant, leaf area index per plant.

Phenological parameters: Number of days to 50% flowering of main pseudostem, number of days to 50% flowering of first ratoon plant, number of days to first appearance of peeper sucker from main pseudostem, number of days to first appearance of peeper sucker from first ratoon plant, number of plantain leaves during flowering of main pseudostem and first ratoon plant.

Yield/yield components: Bunch yield in tonnes per hectare: finger weight in kg per bunch, finger circumference per finger, finger length per finger, number of fingers per bunch, biomass weight in tonnes per hectare, number of bunches harvested per hectare.

2.6. Data Analysis

Data collected were subjected to analysis of variance (ANOVA). Where significant differences were observed, treatment means were separated using the standard error of means (SE) with degree of freedom (d.f) at $P < 0.05$.

3. Results and Discussion

3.1. Weather Condition

The report showed that total amount of rainfall during the two years ranged between 1172-1787.1 mm with a yearly average of 1,420 mm and about two-third of the amount occurred between March and September. The highest annual rainfall of 1787 mm was recorded in 2017 cropping season while 2016 cropping season recorded the least annual rainfall of 1172 mm. The highest relative humidity (116 %) was observed in 2017/2018 cropping season while in 2016/2017 cropping season (56 %) the least relative humidity was observed. The temperatures were relatively similar during the two cropping season ranging from 28.6-39 ^{o}C. The weather of the two growing seasons differed considerably at particular stages of crop growth (Table 1).

3.2. Soil Physical and Chemical Properties before Planting

The result of the analysis of the composite soil sample showed that the soil is sandy, with sand particle content of 91%, clay and silt contents of 7.2 % and 1.8 % respectively (Table 2). The soil was slightly acidic with pH of 6.3. The organic matter content and total nitrogen were high with values 44.7 g/kg and 3.8 g/kg respectively when compared with critical level of 20 g/kg - 30 g/kg and 1.5 g/kg -2.0 g/kg respectively. The available phosphorus was low with value of 5.43 ppm which was lower than critical level of < 10 ppm. The exchangeable cations (Ca, Mg, Na and K) were equally low in status with values of 3.36, 0.08, 0.05 and 0.08 Cmol/kg respectively.

3.3. Effect of NPKMg Fertilizer and Crop Combination on Plant Height of Plantain per Pseudostem

Plantain plants that received 100 kg/ha NPKMg were significantly taller than plants without NPKMg application at 8 and 9 (main pseudostem) and at 21-24 MAP in 2018 (second ratoon plant) [figure 1]. This could be due to insufficiency of native soil nutrient.

In the first ratoon, plantain plants in oil palm/plantain were significantly taller than plants in oil palm/plantain/cassava plots at 15 and 16 MAP (2017), while at 19 and 20 MAP (2017), plantain plants in oil palm/plantain/cassava plots were significantly taller than plantain plants in oil palm/plantain plots. For the second ratoon plants (21-24 MAP) in 2018 plantain plants in oil palm/plantain plots had significantly taller plants relative to plantain plants in oil palm/plantain/cassava plots from 21-24 MAP (Figure 2). This could be due to vigorous growth of plantain plant in oil palm plantain plot as a result of less competition from low plant population. In an intercrop a taller and vigorous component becomes dominant over a shorter slow growing crop (Fukai *et al.*, 2003).

Among the second ratoon plants interaction of oil palm/plantain with 200 kg/ha NPKMg (residual effect of 100 kg/ha NPKMg as first year application and 100 kg/ha NPKMg as second year application) produced significantly taller plants than other treatment interactions at 24 MAP (Table 3).

3.4. Effect of NPKMg Fertilizer and Crop Combination on Number of Suckers per Pseudostem

Plantain plants that received 100kg/ha NPKMg produced more significant number of suckers from first ratoon plants at 17 MAP (Figure 3). Similar effect of fertilizer on plantain growth had been reported by Khalid *et al.* (2009) where they observed that fertilizer increase pseudostem height and increased number of suckers per banana plant.

Plantain plants in oil palm/plantain plots produced more significant number of suckers per pseudostem relative to those in oil palm/plantain/cassava plots from first ratoon plants at 15-18 MAP (2017) and second ratoon plants at 21, 23 and 24 MAP (2018) (Figure 4). Significant increase in number of suckers of first ratoon plant in oil palm/plantain relative to those in oil palm/plantain/cassava plots might be due to early maturity of first ratoon plant from less plant populated plot. This result is in agreement with observation by Akinyemi *et al.* (2010), who reported that widely spaced plants produced more number of suckers.

Interaction of NPKMg application and crop combination were not significantly different at 3-14 MAP (2016-2017), 15-20 MAP (2017) and 21-24 MAP (2018) for main pseudostem, first ratoon plants and second ratoon plants, respectively (Table 4).

3.5. Effect of NPKMg Fertilizer and Crop Combination on Leaf Area Index of Plantain per Pseudostem

NPKMg fertilizer had significant effect on leaf area index of plantain main pseudostem (3-14 MAP) at 12 MAP where plantain plants that received 100 kg/ha NPKMg produced significant higher leaf area relative to those without fertilizer (Figure 5).

Crop combination significantly influenced leaf area index of the main pseudostem at 8 MAP in 2016, of the first ratoon plants at 19 MAP in 2017, where plantain plants in oil palm/plantain plots had significantly higher leaf area index than those in oil palm/plantain/cassava plots (Figure 6).

Interaction of NPKMg application and crop combination were not significantly different at 3-14 MAP (2016-2017), 15-20 MAP (2017) and 21-24 MAP (2018) respectively (Table 5).

3.6. Effect of NPKMg Fertilizer and Crop Combination on Number of Leaves of Plantain per Pseudostem

NPKMg fertilizer had no significant effect on number of leaves per pseudostem from 3-14 MAP (2016-2017) for the main pseudostem, from 15-20 MAP (2017) for the first ratoon plants and from 21-24 MAP (2018) for the second ratoon plants (Figure 7).

Plantain plants planted in oil palm/plantain plots produced significantly more number of leaves per pseudostem than those in oil palm/plantain/cassava plots at 7, 8 and 11 MAP (2016-2017) for the main pseudostem, at 19 and 20 MAP (2017) for first ratoon plants (Figure 8).

Among the main pseudostem, interaction of oil palm/plantain with 118.8 kg/ha NPKMg produced significantly increased number of leaves per pseudostem than other treatment interactions at 11 MAP (2017) [Table 6].

3.7. Plantain Phenological Parameters

NPKMg fertilizer had no significant effect on phenological parameters of plantain from main pseudostem, first and second ratoon plant (Table 7). The similarity observed with number of days to 50% flowering of main pseudostem and first ratoon plant, number of days to first appearance of peeper sucker from main pseudostem with NPKMg fertilizer when compared to plantain that did not receive fertilizer showed that NPKMg fertilizer increased growth at the expense of this parameters, reason could be that climate has more influence on phenological development of plantain than soil nutrient. Generally plantain thrives in rain forest – savanna agro ecology. Akinyemi *et al.* (2010), reported that the optimum temperature for reproductive development of plantain is within 27-34^{0}C, this supports the mean temperature during the 2016 and 2017 which were 32.2^{0}C and 31^{0}C, respectively. Hence the temperature within the cropping season was appropriate for growth and development of cultivated plantain.

Oil palm/plantain/cassava combination significantly delayed days to 50% flowering of main pseudostem and first appearance of pepper sucker from main pseudostem relative to oil palm/plantain combination (Table 7). Significant delay of 185 days and 88 days recorded in number of days to first appearance of peeper sucker and number of days to 50% flowering from main pseudostem, respectively in oil palm/plantain/cassava combination could be due to shortage of nutrient from competition within the component crops in oil palm/plantain/cassava plot. This result support the assertion earlier made that the soil on which the experiment was carried out and not the crop combination alone influenced the development of plantain (Akinyemi *et al.*, 2010). This explains that the increase in plant population leads to significant decrease in soil nutrient and hence increased the days to 50% flowering and appearance of peeper suckers. Ekunwe and Ajayi (2010), made similar observations on the effect of plant density on sucker production and reported that the nutritional status of the mother plant also had an overwhelming influence on sucker production. The environmental component that influences prolonged phenological variations is soil nutrient and moisture availability (Akinrinde, 2006).

Interaction between NPKMg application and crop combination was not significant on phenological parameters of plantain from main pseudostem, first and second ratoon plant (Table 7).

3.8. Cummulative Bunch Yield of Plantain from Main Pseudostem, First Ratoon Plants and Second Ratoon Plants as Affected by NPKMg Fertilizer and Crop Combination

NPKMg fertilizer had no significant effect on bunch yield of plantain (Table 8). Similarity in bunch weight from NPKMg fertilized and unfertilized plots could be due to sufficient native soil nutrient or sandy nature of the soil which must have lead to leaching of fertilizer. This result explains the low percentage of K in soil treated with fertilizer as was seen in soil analysis result at the end of the trial. This further explains that K was not translated into corresponding bunch yield of plantain. Result is in conformity with that reported by Akinyemi *et al.* (2003), that fertilizer did not significantly increase the yield of plantain. Shiyam (2010), have suggested application of fertilizer boost growth of plantain without any effect on bunch yield.

Significant difference was observed with finger length per finger where plantain plants in oil palm/plantain/cassava plots produced longer finger length per finger relative to those from oil palm/plantain plots (Table 8). The increase in finger length in plantain in oil palm/plantain/cassava relative to those in oil palm/plantain plots may be due to the season and time of flowering of plantain main pseudostem in oil palm/plantain/cassava plot. Plantain main pseudostem in oil palm/plantain plot produced bunch in January up till March, the period during which the plants become dehydrated as a result of the dry spell in five months while plantain main pseudostem in oil palm/plantain/cassava plot produced bunch from July- September during the peak of the rain. This explains that climatic condition has influence on bunch yield. Ekunwe and Ajayi (2010), suggested that plantain in less populated area tends to flower earlier than those in highly populated area. Similarly Rasheed (2003) observed that progressive decline in plantain yield over the years was attributed to high susceptibility to drought and low nutrient status of the soil. Bauri *et al.* (2002) reported that first harvest from June gave good fruit quality while El-Khawaga (2013) observed that time of crop harvest should be considered for better growth and fruit development. Plantain in oil palm/plantain/cassava and oil palm/plantain plots produced similar bunch weight; this implies that the presence of cassava did not negatively influence the bunch weight of plantain in oil palm/plantain/cassava plots. This might be due to the fact that cassava provided shade which prevented excess effect of solar radiation on the soil and improved soil moisture content. This suggests that in this study bunch weight was not reduced by competition for available nutrient accumulated over time. These results were in contrast with those earlier reported that average bunch yield of plantain increased with decreased planting densities (Kesavan *et al.*, 2002). Generally the bunch weight distribution

of plantain also followed the rainfall pattern throughout the two cropping seasons of this experiment. Plantain has been found to respond to adequate soil moisture and it preferred rainfall as high as 800- 1500 mm (Hall, 2000).

The interactions of NPKMg application and crop combination were not significant on plantain bunch yield from 2017-2018 (Table 8).

4. Conclusion

NPKMg fertilizer resulted to increased growth (plant height and leaf area index) and number of sucker production of plantain plant, it however did not increase bunch yield. Plantain plant in oil palm/plantain combinations recorded increase growth (plant height and number of sucker per plant) of plantain plant while Oil palm/plantain/cassava (OPPC) combination increase the finger lenght, delayed 50% flowering and first appearance of peeper suckers than those in OPP combination.

References

Agrobrief (2011). *Intercropping of annual food crops. Agromisa Foundation, Google Scholaraikh.* 4 vols. H., Varadachari, C. and Ghosh, K. 1998b. Effects of deforestation. 10.

Akinrinde, E. A. (2006). Issues of optimum nutrient supply for sustainable crop production in tropical developing countries. *Pakistan Jour. of Nutrition*, 5(4): 387-97.

Akinyemi, S. O. S., O., O. A. and Tijani-Eniola, H. (2003). Effect of Potassium fertilizer on yield of plantain –melon intercropped on an Oxic Paleustalf in south western Nigeria. Available: http://agronomyaustraliaproceedings.org/images/sampledata/2004/poster/2/5/5/297_olaleyeao.pdf

Akinyemi, S. O. S., Aiyelaagbe, I. O. O. and Akyeampong, E., 2010. "Plantain (musa spp.) cultivation in Nigeria: A review of its production, marketing and research in the last two decades." In *Proc. IC on Banana and Plantain in Africa Eds.: T. Dubois et al. Acta Hort. 879, ISHS 2010.*

Bauri, F. K., Misra, D. K. and Sarkar, S. K. (2002). Effect of planting time on post-harvest performance of banana cv. *MArtaman. Indian Jour. of Hort.*, 59(2): 127-29.

Bonneau, X., R., I. and Buabeng, M. (2014). Optimum oil palm Planting density in West Africa. 21(4): 1-10. Available: www.ocl.Journal.org

Diemier, P., Chinchilla, C. and Grifferere, P., 2004. "Small holder oil palm manual." In *Food and Agricultural organization of the United Nations Rome, Italy.*

Ekunwe, P. A. and Ajayi, H. I. (2010). Economics of plantain production in Edo State Nigeria. *International Journal of Agric. Econs. and Rural Dev.*, 2(4): 25-31.

El-Khawaga, A. S. (2013). Adjusting the best time of planting suckers and plant density for William Banana grown under Aswan Region Conditions. *Asian Jour. of Crop Sci.*, 5(3): 251-63.

Fukai, S., Alco, A. B., Llamelo, A. B. and Patterson, R. D. (2003). Effects of solar radiation on growth of cassava (*Manihotesculentacrantz*.) 1. Canopy development and dry matter growth. *Field Crops Research*, 19: 347-60. Available: https://www.sciencedirect.com/science/article/abs/pii/0378429084900388

Hall, A. E. (2000). *Crop responses to environment.* FL: CRC press: Boca Raton.

Kesavan, V., Hil, T. and Morris, G. (2002). The effect of plant spacing on growth, cycling time and yield of bananas in subtropical Western Australia. *Acta Hortic*, 575: 851-57. Available: http://dx.doi.org/10.17660/ActaHortic.2002.575.101

Khalid, L., Al-Harthi, I. and Rashid, A. (2009). Effect of NPK fertilizer on growth and yield of banana in Northern Oman. *Journal of Hort. and Forestry*, 1(8): 160-67. Available: http://www.academicjournals.org/jhf

Okpala – Jose, A., Utulu, S. N., Eneh, F. K. and Onwubuya, I. I. (1996). Development of a sustainable oil palm food crop Farmers system. 1 Development of standard oil palm spacing for continuous intercropping. Nigerian institute for Oil Palm Research (NIFOR), Final report on the priority research projects and research extension farmer's linkage system of the National Agriculture Research Project (NARP).

Rasheed, A. (2003). Plantain Production as a business. *Horticulture Magazine*, 1(1): 11-12.

Robert, L. M. (2004). Nutrient plants require for growth. College of Agriculture and Life Science.Published November 2004. *Research Journal of Agriculture and Biological Sciences*, 6(6): 902-05.

Shiyam, J. O. (2010). Response of plant and ratoon crop plantain to potassium fertilization in the tropical rain forest zone of Nigeria. *Acad. Jour. of Plant Sci.*, 3(3): 126-29.

Table-1. Weather data during the period of experimentation (2016-2018) at Obazuwa village

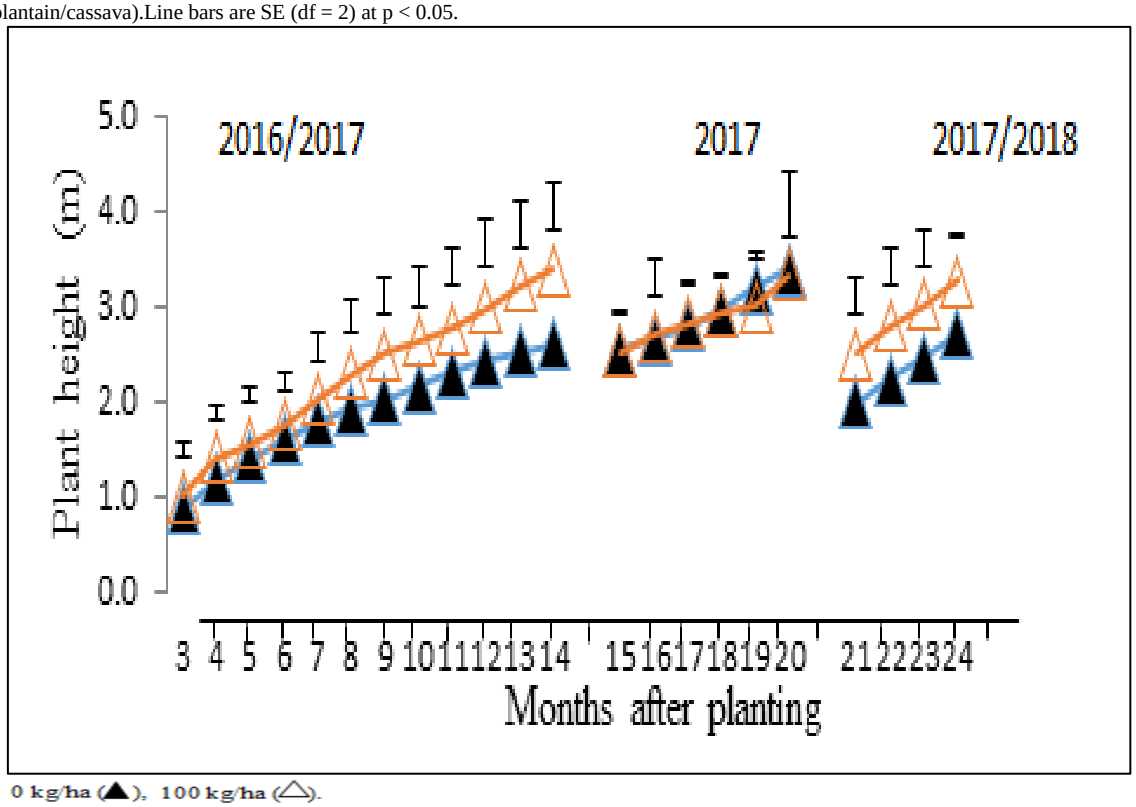
Months	Total Rainfall (mm)			Temperature (°C)			Relative Humidity (%)			Sunshine (Hours)		
	2016	2017	2018	2016	2017	2018	2016	2017	2018	2016	2017	2018
Jan	0.0	0.0	2.0	35	32.7	35.0	58.3	80.4	46.9	5.5	3.4	5.1
Feb	7.0	2.0	9.0	34.7	35.0	33.6	76.7	79.6	42.1	4.1	2.0	3.7
Mar	155	113.0	126	33.5	34.9	33.8	78.4	81.3	73.3	5.7	3.0	5.3
Apr	84.6	132.8	54.0	34	38.6	34.2	81.4	83.9	64.6	5.6	5.0	5.2
May	133	275.9	146	32.2	33.9	32.5	95.4	82.6	53.7	5.9	6.1	5.5
Jun	179	178.1	152	30.4	30.7	30.5	81.8	87.9	59.5	4.3	4.2	3.9
Jul	201	246.1	213.6	28.6	33.3	31.7	85.0	88.8	51.6	2.7	2.2	1.6
Aug	208	338.9	263	29.3	34.8	33.2	84.4	88.6	52.9	2.1	2.5	2.6
Sep	175	252.7	203.9	30.4	31.6	30.0	80.7	87.5	50.8	2.8	2.5	2.4
Oct	19.7	157.7	98.7	32	39.0	37.4	81.6	84.9	47.7	4.7	3.3	3.2
Nov	6.0	58.8	22.4	33	33.6	32.0	83.0	84.7	40.5	6.1	4.3	5.5
Dec	3.6	31.1	9.35	33.7	33.6	31.9	76.3	82.6	33.45	6.5	2.5	5.9
Mean	97.7	148.9	108.33	32.2	34.3	33.0	80.2	84.4	54.4	4.6	9.7	10.2

Source: NIFOR Agro-meteorological station, 2016- 2018

Table-2. The soil physical and chemical properties of the experimental location before the commencement of the experiment in 2016

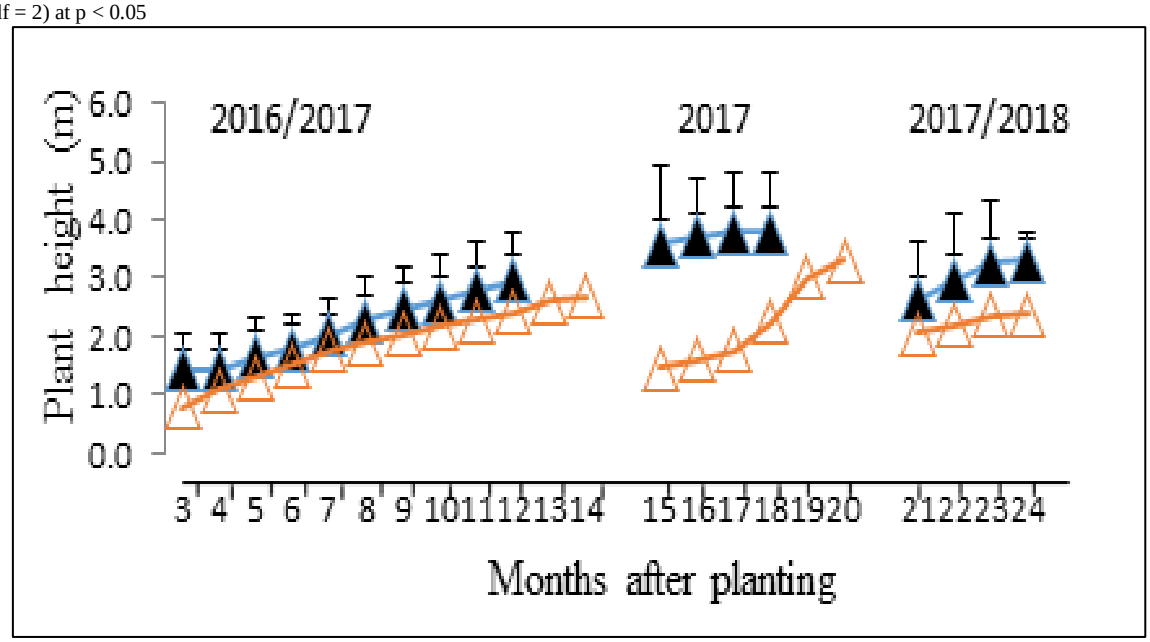
Soil Properties	Results
pH (1:1 H_20)	6.30
EC (µS)	545
Organic carbon (%)	2.60
Organic matter (%)	4.47
Total Nitrogen (%)	0.38
Available-P (ppm)	5.43
Exchangeable cations (meq/100g soil)	
Ca	3.36
Mg	0.08
Na	0.05
K	0.08
Particle Size Distribution	
Sand (%)	91
Silt (%)	1.80
Clay (%)	7.20
Textural class	Sandy soil

Figure-1. Effect of NPKMg fertilizer on plant height of plantain Irrespective of crop combination (oil palm/plantain and oil palm/plantain/cassava).Line bars are SE (df = 2) at $p < 0.05$.



0 kg/ha (▲), 100 kg/ha (△).

Figure-2. Effect of crop combination on plant height of plantain Irrespective of fertilizer application (with and without fertilizer). Line bars are SE (df = 2) at p < 0.05



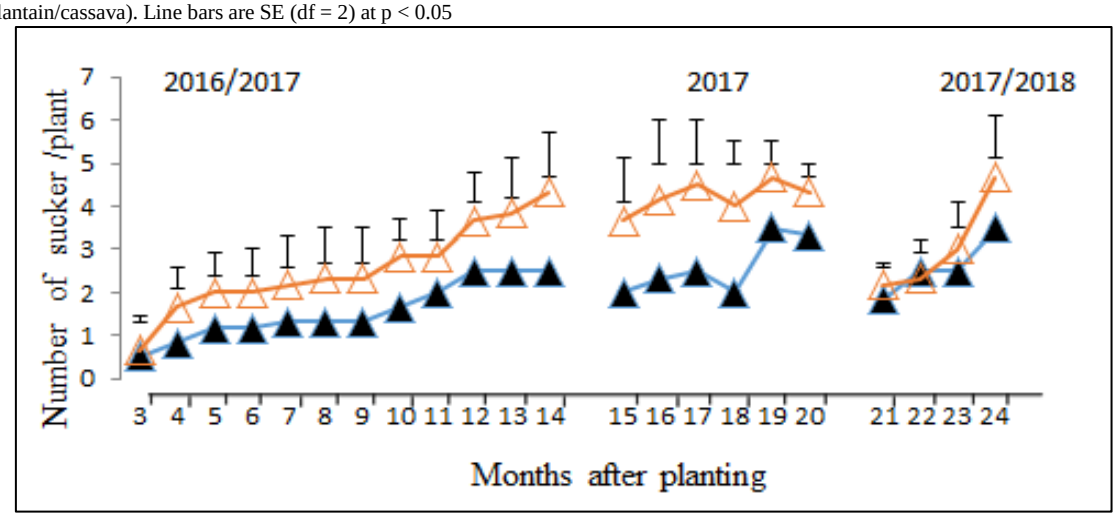
Oil palm /plantain/cassava (△) Oil palm /plantain (▲),

Table-3. Interaction between NPKMg fertilizer and crop combination on plant height (m) of plantain main pseudostem, first ratoon plant and second ratoon plant

		Main pseudostem											
NPKMg rates (Kg/ha) / Crops		**2016**							**2017**				
2016		3*	4	5	6	7	8	9	10	11	12	13	14
0	OPP	0.99	1.37	1.64	1.74	1.92	2.05	2.18	2.32	2.51	2.62	2.74	2.80
0	OPPC	0.72	0.91	1.14	1.43	1.64	1.77	1.86	1.98	2.12	2.21.	2.30	2.38
118.8	OPP	1.12	1.52	1.65	1.84	2.14	2.53	2.79	2.88	3.09	3.31	3.52	3.72
207.0	OPPC	0.88	1.26	1.46	1.62	1.89	2.06	2.21	2.37	2.44	2.64	2.89	3.02
SE(± 0.05, d.f 2)		0.35	0.27	0.26	0.22	0.17	0.24	0.26	0.27	0.39	0.46	0.52	0.61
		First ratoon plant						Second ratoon plant					
		2017						2018					
2017		15	16	17	18	19	20	21	22	23	24		
0	OPP	3.64	3.74	2.45	1.29	0	0	2.29	2.56	2.86	3.21		
0	OPPC	1.44	1.54	1.73	2.38	3.02	3.18	1.65	1.90	2.05	2.21		
137.6	OPP	3.51	3.68	3.83	1.21	0	0	2.99	3.34	3.66	0		
225.8	OPPC	1.52	1.67	1.80	2.13	2.98	3.46	2.01	2.22	2.37	2.52		
SE(± 0.05, d.f 2)		0.24	0.24	0.90	1.44	0.33	0.21	2.19	1.87	1.59	6.56		

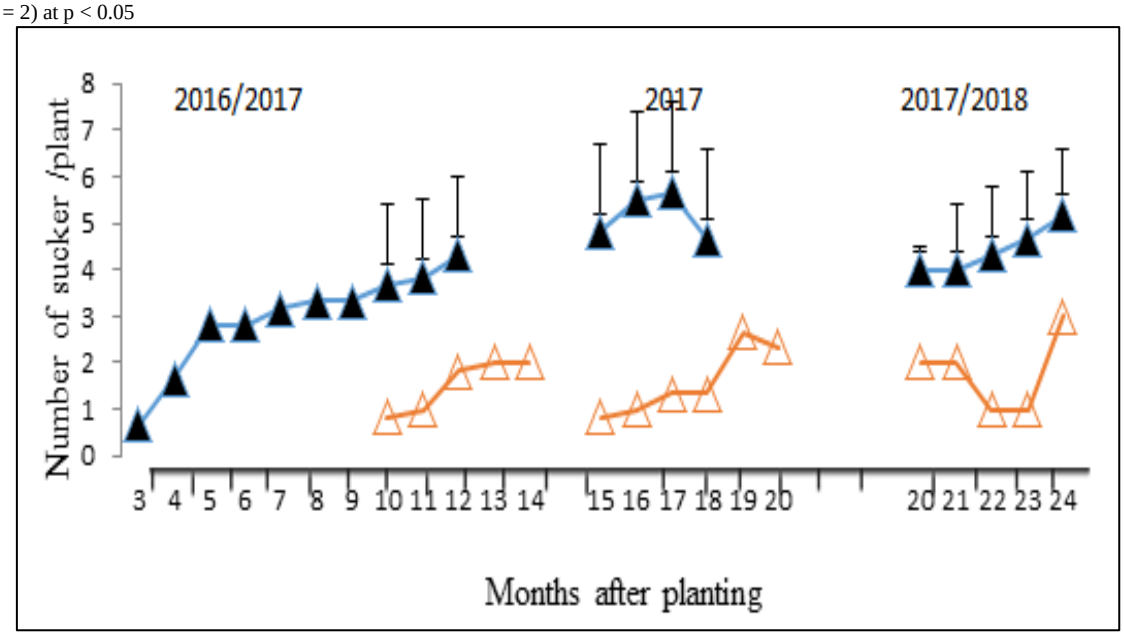
Months after planting, OPPC-oil palm/plantain/cassava, OPP- oil palm/plantain, SE-standard error of means

Figure-3. Effect of NPKMg fertilizer on number of suckers per plant irrespective of crop combination (oil palm /plantain and oil palm/plantain/cassava). Line bars are SE (df = 2) at p < 0.05



0 kg/ha (▲), 100 kg/ha (△).

Figure-4. Effect of crop combination on number of suckers per plant irrespective of NPKMg fertilizer (with and without fertilizer). Line bars are SE (df = 2) at $p < 0.05$



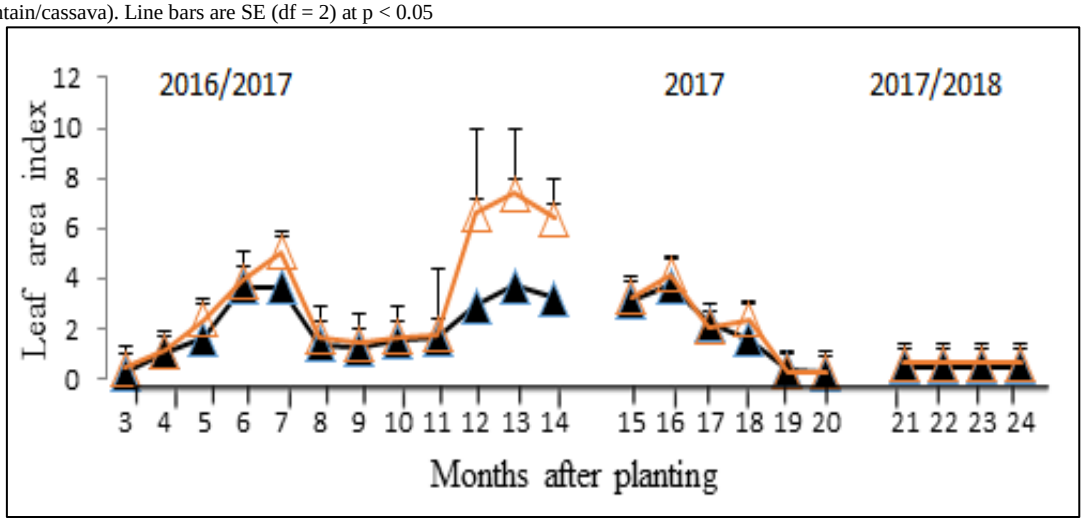
Oil palm /plantain/cassava (△) Oil palm /plantain (▲),

Table-4. Interactions between NPKMg fertilizer and crop combination on number of sucker of plantain main pseudostem, first ratoon plant and second ratoon plant.

Main pseudostem													
NPKMg rates (Kg/ha) / Crops		**2016**							**2017**				
2016		3*	4	5	6	7	8	9	10	11	12	13	14
0	OPP	0	1	2	2	3	3	3	3	3	3	3	3
0	OPPC	0	0	0	0	0	0	0	0	1	2	2	2
118.8	OPP	1	3	3	3	3	4	4	3	3	5	5	6
207.0	OPPC	0	1	1	1	1	1	1	1	1	2	2	2
SE(± 0.05, d.f 2)		0.24	0.94	1.20	1.20	1.31	1.47	1.47	1.49	1.60	1.56	1.49	1.49
First ratoon plant								Second ratoon plant					
		2017						2018					
2017		15	16	17	18	19	20	21	22	23	24		
0	OPP	4	5	5	5	5	5	4	4	4	4		
0	OPPC	0	0	0	1	2	2	0	1	1	3		
137.6	OPP	6	6	6	6	6	6	4	5	5	6		
225.8	OPPC	1.67	2	2.67	2	3	3	0	0	1	3		
SE(± 0.05, d.f 2)		0.97	0.88	1.05	0.67	0.94	1.08	2.03	2.01	1.62	1.65		

*Months after planting, OPPC-oil palm/plantain/cassava, OPP- oil palm/plantain, SE-standard error of means

Figure-5. Effect of NPKMg fertilizer on leaf area index per plant irrespective of crop combination (oil palm /plantain and oil palm/plantain/cassava). Line bars are SE (df = 2) at $p < 0.05$



0 kg/ha (▲), 100 kg/ha (△).

Figure-6. Effect of crop combination on leaf area index per plant irrespective of NPKMg fertilizer (with and without fertilizer). Line bars are SE (df = 2) at p <0.05

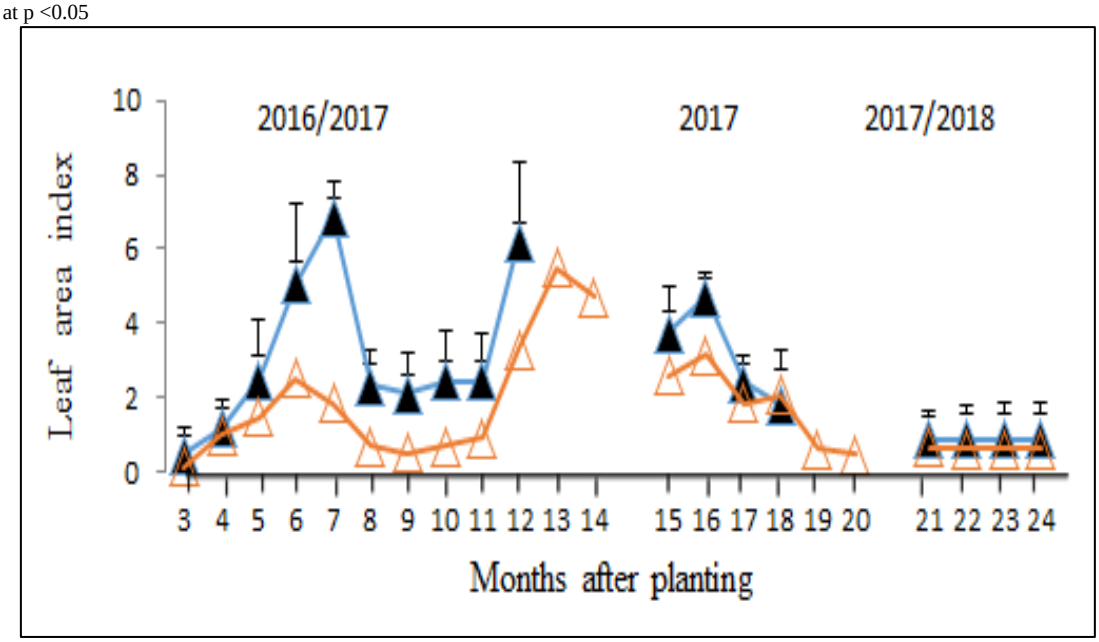


Table-5. Interaction between NPKMg fertilizer and crop combination on leaf area index of plantain main pseudostem, first ratoon plant and second ratoon plant

Main pseudostem													
NPKMg rates (Kg/ha) / Crops		**2016**							**2017**				
2016		3*	4	5	6	7	8	9	10	11	12	13	14
0	OPP	0.31	1.03	2.41	5.14	6.24	2.25	1.99	2.49	2.63	3.59	4.10	3.10
0	OPPC	0.09	1.10	0.85	2.18	1.11	0.53	0.41	0.51	0.62	2.24	3.40	3.30
118.8	OPP	0.64	1.37	2.58	4.95	7.50	2.44	2.24	2.43	2.29	8.84	7.20	6.60
207.0	OPPC	0.2	0.89	2.14	2.89	2.59	0.85	0.64	0.88	1.21	4.37	7.60	6.20
SE(± 0.05, d.f 2)		0.35	0.34	0.63	0.73	0.86	1.53	0.64	0.66	0.53	0.62	2.88	4.51
		First ratoon plant						Second ratoon plant					
		2017						2018					
2017		15	16	17	18	19	20	21	22	23	24		
0	OPP	3.7	4.61	1.95	1.34	0	0	0.64	0.76	0.90	0.90		
0	OPPC	2.49	2.80	2.46	1.80	0.69	0.45	0.26	0.08	0.63	0.63		
137.6	OPP	3.82	4.82	2.86	2.33	0	0	0.83	1.03	0.41	0.31		
225.8	OPPC	2.71	3.53	1.24	2.39	0.57	0.50	0.44	0.23	0.90	0.90		
SE(± 0.05, d.f 2)		1.85	1.28	1.77	0.62	0.30	0.21	0.34	0.51	0.32	0.70		

*Months after planting, OPPC-oil palm/plantain/cassava, OPP- oil palm/plantain, SE-standard error of means

Figure-7. Effect of NPKMg fertilizer on number of leave per plant irrespective of crop combination (oil palm /plantain and oil palm/plantain/cassava). Line bar are SE (df = 2) at p < 0.05.

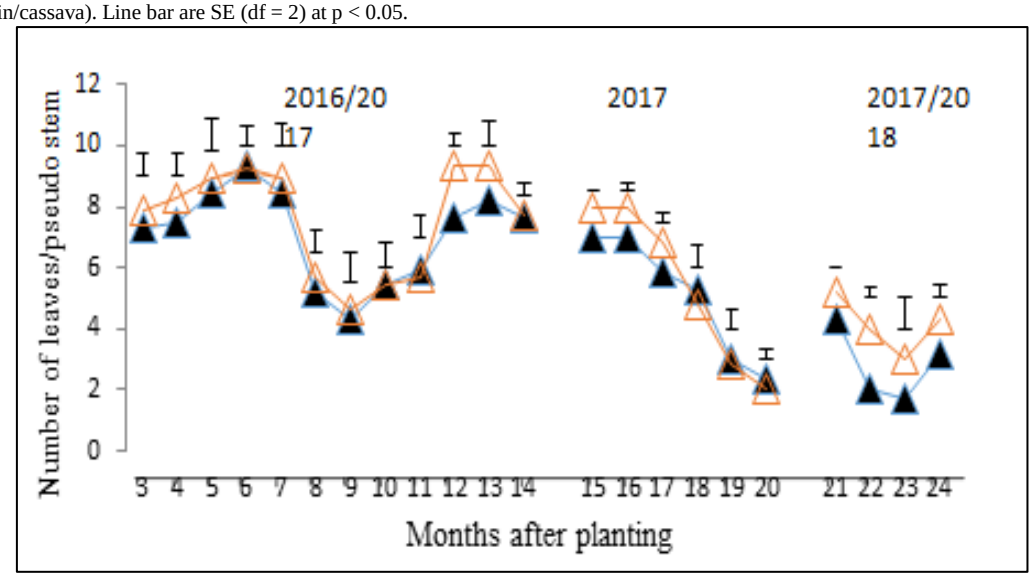


Figure-8. Effect of crop combination on number of leaves per plant irrespective of NPKMg fertilizer (with and without fertilizer). Line bars are SE (df = 2) at $p < 0.05$

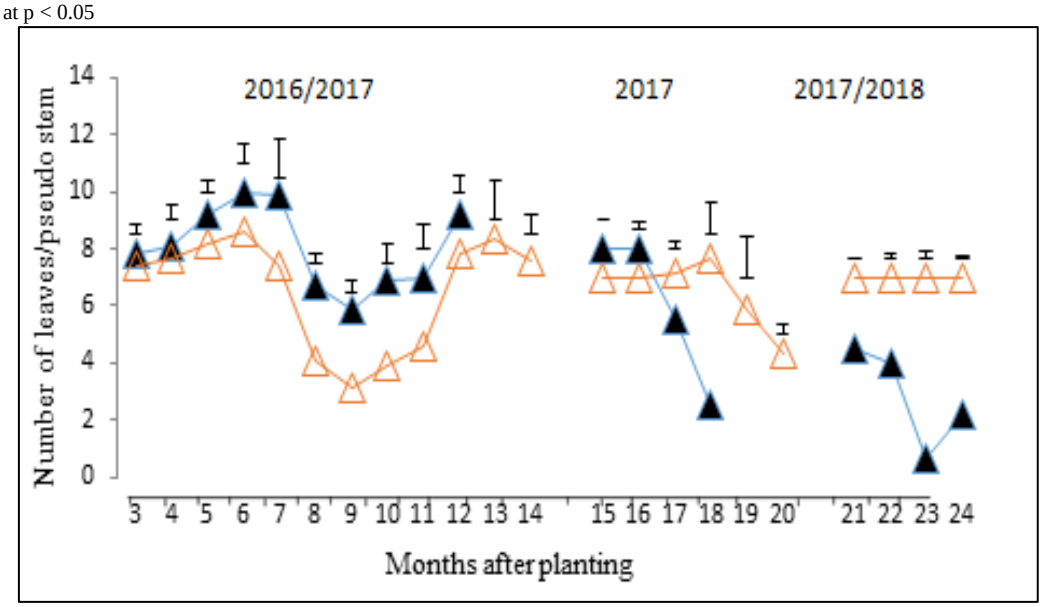


Table-6. Interaction between NPKMg fertilizer and crop combination on number of leaves of plantain main pseudostem, first ratoon and second ratoon

Main pseudostem													
NPKMg rates (Kg/ha) / Crops		**2016**							**2017**				
2016		3*	4	5	6	7	8	9	10	11	12	13	14
0	OPP	7	7	9	19	10	7	6	7	8	8	9	8
0	OPPC	7	8	8	9	7	4	3	4	4	7	8	8
118.8	OPP	8	9	9	10	10	7	6	7	6	10	10	8
207.0	OPPC	8	8	9	9	8	5	4	4	5	9	9	8
SE(± 0.05, d.f 2)		0.91	1.20	0.94	1.53	0.83	1.07	1.09	1.17	0.67	1.59	0.80	0.38
		First ratoon plant						Second ratoon plant					
		2017						2018					
2017		15	16	17	18	19	20	21	22	23	24		
0	OPP	8	8	4	3	0	0	4	4	3	5		
0	OPPC	6	6	7	8	6	5	4	0	0	1		
137.6	OPP	8	8	7	2	0	0	6	0	5	6		
225.8	OPPC	8	8	7	7	6	4	5	0	1	3		
SE(± 0.05, d.f 2)		0.41	0.41	1.39	2.6	0.47	0.75	0.33	1.47	1.11	1.18		

*Months after planting, OPPC- oil palm/plantain/cassava, OPP- oil palm/plantain, SE-standard error of means

Table-7. Effect of NPKMg fertilizer application, crop combination and interaction on phenological parameters of plantain

2016 2017 NPKMg rate (kg/ha)		**Number of days to 50% flowering of Main pseudostem**	**Number of days to 50% flowering of first ratoon plant**	**Number of days to first appearance of peeper sucker from main pseudostem**	**Number of leaves at flowering from main pseudostem**	**Number of leaves at flowering from first ratoon plant**
0	0	412	520	235	7	7
100	100	397	488	180	8	8
SE (±0.05, d.f 2)		7.07	7.00	23.20	0.41	0.44
Crops						
OPP	OPP	360	499	115	8	7
OPPC	OPPC	448	508	300	7	7
SE (±0.05, d.f 6)		7.10	5.70	34.80	0.62	0.88
Fertilizer rate x Crops						
0	0	OPP 360	525	130	8	7
0	0	OPPC 475	514	340	7	7
118.8	137.6	OPP 348	474	100	9	8
207.0	225.8	OPPC 430	502	260	6	7
SE (0.05, d.f 6		10.02	9.0	41.80	0.75	1.05

OPPC-oil palm/plantain/cassava, OPP- oil palm/plantain, SE-standard error of means

Table-8. Effect of NPKMg fertilizer application, crop combination and interaction on plantain yield

2016 2017 NPKMg rate (kg/ha)			**Finger weight (kg/bunch)**	**Finger circumference per finger(cm)**	**Finger length per finger (cm)**	**Number of fingers per bunch**	**Biomass weight (t/ha)**	**Number of bunches per ha**	**Bunch weight (t/ha)**
0	0		0.17	12.2	24.5	20.7	23.3	5370	4.52
100	100		0.18	13.0	24.5	25.3	28.6	5741	5.32
SE (±0.05, d.f 2)			0.03	0.24	0.35	1.01	1.97	186.7	0.21
Crops									
OPP	OPP		0.16	12.5	23.5	22.0	24.3	5834	4.43
OPPC	OPPC		0.19	12.7	25.0	24.0	27.6	5279	5.40
SE (±0.05, d.f 6)			0.03	0.47	0.20	1.34	0.93	278.2	0.38
Fertilizer rate x Crops									
0	0	OPP	0.21	12.00	23.00	19.7	19.63	5741	4.00
0	0	OPPC	0.28	12.33	26.00	21.7	27.03	5000	5.03
118.8	137.6	OPP	0.26	13.00	24.00	24.3	29.00	5926	4.87
207.0	225.8	OPPC	0.27	13.00	25.00	26.3	28.17	5556	5.77
SE (0.05, d.f 6)			0.14	0.53	0.41	1.67	2.18	383.3	0.44

OPPC-oil palm/plantain/cassava, OPP- oil palm/plantain, SE-standard error of means