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EFFECT OF INTERCROPPED AND PHOSPHATE FERTILIZER ON THE GROWTH AND YIEDS OF RUBBER AND COCOYAM ON AN ULTISOL IN SOUTHERN NIGERIA

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ABSTRACTS

A two season field experiment was carried out at the Rubber Research Institute of Nigeria (RRIN) to evaluate the effect of matured rubber shade and rock phosphate fertilizer on the physiological growth of cocoyam and the yield of cocoyam and rubber intercropped in southern Nigeria. The trial was a factorial experiment arranged in a randomized Complete Block Design with each treatments replicated thrice. Data were generated on the physiological growth characteristics (Height, girth and number of leaves and leaf area) and the yield of cocoyam (corm) and rubber (latex). The results indicated that intercropping with matured rubber reduces the edible cormel yield of cocoyam by 27, 23, and 65% in the 0, 60 and 120 kgPha^{-1} treatments respectively. It also delayed the leaf shedding of cocoyam by about 9 weeks. However, the latex yield of rubber was not significantly affected by cocoyam intercropping. Land Equivalent Ratio (LER) values of 1.31, 1.60 and 1.68 were obtained from 0, 60 and 120 kg P ha-1 treatments respectively in the rubber/cocoyam intercrops indicating higher land use efficiency in intercropping cocoyam with matured rubber than planting cocoyam or rubber as sole crop. The higher land use efficiency and the possibility of securing subsistence through arable cropping while simultaneously gaining cash income through rubber latex would make cocoyam intercropping with matured rubber attractive to small holder farmers and ultimately increase the land area under rubber plantation in Nigeria.

Keywords: Rubber, Cocoyam, Intercropping, Rock Phosphate fertilizer, Growth. Yield, LER

INTRODUCTION

Rubber cultivation in Nigeria faces a major constraint due to population pressure. This situation is compounded by the fact that large expanse of land is required for rubber plantation establishment and over 70% of the interrow underutilized. To put the small-scale farmers and other investors on a sound economic footing, rubber farming systems designs must ensure optimal utilization inter-row to harness the biological and agricultural benefits of various cropping systems (Idoko, *et al.*, 2010 and Wasana and Thatil, 2001). Scientists have suggested intercropping of annual and perennial crops with rubber for optimal use of spaces between the rubber trees (Esekhade and Ojiekpon, 1997; Esekhade *et al.*, 2003). This approach explores the natural resources in the plantation and also safeguards the systems such that resource use is more efficient and sustainable. Arable cropping in the interrowof rubber before canopy closure has been found to attract small holders to the business of rubber farming, brings about higher gross, returns on investments and shortens the long gestation period of rubber (Esekhade et al. 2003) and Rodrigo et al. 2004).

At military, however rubber canopy closes up thus limiting the above ground resources available to companion crops. It follows therefore that studies need to be conducted on possible ways of bringing this seemingly wastelands under rubber plantations into economic production using shade tolerant crops such as cocoyam.

Cocoyam (*Colocasia esculentus*)has been found to grow appreciably well with other plantation crops such as Cocoa, kola, citrus, oil palm and Plantain in Southern Nigeria (Undealor *et al.* 1980, Utomakili and Agunbiade, 1995) showing that cocoyam can tolerate shade and utilize effectively the above-ground resources that are limiting in rubber plantations if enough provisions are made for their nutrition.

This study therefore investigates the viability of intercropping cocoyam with matured rubber plantation and the utilization of phosphate rock fertilizer applied to cocoyam under a matured rubber plantation.

MATERIALS AND METHODS

A field experiment was conducted at the Rubber Research Institute of Nigeria (RRIN) main station at Iyanomo near Benin City South West longitudes 5°35- 5°55'E and latitude 6°05'- 6°25' N with a hot humid climate. Mean annual temperature and rainfall is about 27C and 2000mm respectively.

The field used was the clonal garden planted to RRIN developed clones (NIG 800 series) of rubber. The plantation was established in 1991 from a land under prolonged fallow period of over 12 years with no history of fertilizer usage prior to plantation. The rubber was planted at a spacing of 6.7 x 3.4 m. Three years after plantation establishment, a blanket application of NPK 15-15-15 was carried out. Weeding has always been by manual slashing. The plantation was opened for tapping in the year 2000.

The experiment was arranged in a randomized complete block design with nine (9) treatment combinations in three replicates giving a total of 27 experimental units. The treatments were three cropping systems (sole rubber, sole cocoyam and rubber cocoyam) and P fertilizer levels (0, 60 and 120kg P ha). Each plot measured 98 m^2 with four stands (one per stand) of Rubber (NIG 804) in each plot. Cocoyam (*Xantosoma sagitifolium*) (Local) was introduced into the inter-rows 10 years after the rubber establishment and two years after the commencement of tapping. The cocoyam was intercropped with rubber at a spacing of 90 x 90 cm and one meter away from the rubber stands making effective use of the avenues of rubber. Acidulated Moroccan Rock Phosphate (27.4% P_2O_5) was applied at three levels corresponding to 0(control), 60 and 120 kg P ha^{-1} as treatments. Basal rates of Muriate of Potesh (609% K_2O), Urea (45%N) were applied to all the plots at 40 and 49.8 kg P ha^{-1}. Soil samples were collected from each plot before treatments were imposed and after the cocoyam harvests. The samples were subjected to routine soil analysis using standard laboratory procedures described in IITA manual (1979). Data on cocoyam growth characteristics and latex yield of rubber were taken at a monthly interval. Yield and yield components of cocoyam were accessed at harvest from a random 4 m^2 area in each plot containing cocoyam.

Field and laboratory data collected were subjected to statistical analysis using Variance (ANOVA) in randomized complete block design and mean separation was by least significant difference (LSD) procedures.

RESULTS AND DISCUSSION

Soil Chemical Properties

The effects of cropping systems and P application on soil properties before planting and after harvest are shown in Table 1. It was observed that intercropping cocoyam with matured rubber consistently showed marginal increases in soil chemical properties compared with the sole treatments of rubber and cocoyam. An average of 0.87, 5.44 and 12.95 percent increases in available P (Bray 1) in the 0, 60 and 120 kg P ha fertilizer treatments respectively. This increases in soil available P even in plots that received no P treatment may be attributable to the mineralization of organic P resulting from soil disturbances in normal cultivation processes. Agboola and Okoh (1976), Idoko, *et al.*, (2010) and Esekhade *et al.*, (2017) had attributed variations in crop responses in similar soils to P mineralization, and suggested that organic P mineralization may be a major determinant of P fertility and availability in soils high in Fe and Al oxides. Similarly, rubber intercropped with cocoyam increased the soil organic carbon by 10, 15 and15% respectively in the 0, 60 and 120kg P ha fertilizer treatments respectively. This is consistent with the observations of Bunsh (2002) and Esekhade *et al.*, (2014) that annual crops intercropped with perennial crops leads to ahigher biomass production and organic matter build-up in the soil systems. The build up further enhances microbial activities leading to the release of other nutrients such as P to the soil (Hulugalle and Ezumar, 1991, Zainol et al. 1993 and Idoko *et al.*, 2010). The soil pH increased consistently from 4.60 4.84, 4.81 4.86 and 5.07 5.39 in the sole rubber, sole cocoyam and rubber +cocoyam cropping systems respectively. The increases in pH are not statistically significant but in practical terms, may have far-reaching effects on the availability of soil nutrients. The effects of increasing P rates on pH may partly be attributed to the liming ability of rockphosphate in acid soils being primarily Calcium phosphate (Orimoloye et al, 2004).

Effect of Cropping Systems and P fertilizer on Cocoyam Growth Characteristics and Yields

The vegetative growth characteristics of cocoyam in sole cropping and under rubber revealed that cocoyam grows more luxuriantly when planted sole than when intercropped with matured rubber during the rainy season . However, at the early dry season (Late September – October), cocoyam planted as sole dries while those intercropped with rubber maintain fresh green leaves far into the dry season (November - December) indicating that rubber shade prolongs the vegetative growth period of cocoyam in mixtures compared with sole cropping. This could be attributed to the effects of rubber canopy that tends to alter the micro climate resulting in fluctuations in temperature, higher relative humidity, carbon balance, and soil moisture (Wan, 1994). In places where cocoyam leaves are eaten or fed to livestock (e.g. Snailery), intercropping cocoyam with rubber ensures the supply of fresh cocoyam leaves when the sole cropped cocoyam leaves had dried out.

The effects of P fertilizer and intercropping on cocoyam edible cormel yield and yield related characteristics are presented in Table 2. The results show that cocoyam planted sole has a significantly ($P \leq 0.05$) higher cormel yield compared to those intercropped with matured rubber producing a mean cormel yield of 4.25, 3.24 and 6.03 Kgha^{-1} in the 0, 60 and 120 kg P ha^{-1} fertilizer treatments respectively compared with 2.43, 2.04 and 1.28 Kgha^{-1} in the 0, 60 and 120 kg P ha^{-1} fertilizer treatments in the intercropped cocoyam. This could be attributed to the zero competition for the growth resources in the sole cocoyam cropping system. However, the effect of P fertilizer on cormel yield did not follow a definite patter in the sole and intercropped cocoyam plots. In the sole crops, 60 kgP ha^{-1} seemed to depress the cocoyam yield, as the yield reduced with increasing rates of P application. Similar patterns are followed by other yield components of cocoyam such as corn (non-edible) yield, mean cornel weight, cormel length and diameter. The cormelsin the cocoyam sole cropping system tend to be more robust than those intercropped with rubber. This is expected to attract higher prices in the local market due to consumer preferences.

Rubber Latex Yield and Land Use Efficiency

The rubber latex yield and the land use efficiency estimated by land equivalent ratio (LER) of the cropping systems as affected by P fertilizer treatments are presented in Table 3. The P fertilizer treatments as well as the cropping systems involved had no significant effect on rubber latex yield. Rubber plots treated with 0 kg P ha^{-1} and 120kg P ha^{-1} in the intercrop gave a marginal latex yield of 3% and 5% respectively over the sole rubber treatments, while the 60kg P ha^{-1} treatment had their yield reduced by 2%. The dynamics of P in acid soils is so complex as observed by Curtin *et al.*, (1992), particularly in soils that are rich in metal oxihydroxides that can form chemical bonds with phosphate ions (lyamuremye *et al.* 1996). It is therefore difficult to adduce reasons for the latex yield behavior of rubber at this stage, but this is being investigated further. However, since the rubber latex yield increased marginally in intercrop systems with cocoyam. It is an indication that planting cocoyam in the avenues of rubber does not pose any threat to the latex yield of rubber. In spite of the cocoyam yield reduction of 43%, 37% and 79% in the 0, 60 and 120kg P ha^{-1} treatments respectively in rubber + cocoyam cropping systems, the LER of 1.68, 1.60 and 1.31 obtained showed that intercropping rubber with cocoyam resulted in a higher land use efficiency of 68%, 60% and 31% in the 0, 60 and 120kg P ha treatments respectively. This is consistent with the observations of previous intercrop studies that showed that there are reductions in the yield of crops under intercropping compared to the ones under sole cropping treatments. The overall LER of more than one (1) obtained indicates the advantages of intercropping. Also, in rubber intercropping studies before canopy closure, similar observations were made by Esekhade and Ugwa (1999), Esekhade et al. 2003 and Esekhade *et al.*, 2014.

CONCLUSION

This study showed that rubber latex yield was not significantly reduced when intercropped with cocoyam. Though, the unit area of land in rubber + cocoyam intercropping is between 31 and 68% higher than when both crops are planted as sole crops. The combination of subsistence and cash cropping with high level of productivity on a small land area will be more attractive to smallholder famers because production risks are very minimal and the environment is sustained.

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Table 1 Soil Chemical properties before application of treatments

Treatments cropping system	**Fertilizer (Kg/ha)**	**pH** Before	After	Org. C (%) Before	After	**P** (Cmol kg-1) Before	After	**Na** (Cmol kg-1) Before	After	Mg (Cmol kg-1) Before	After	K (Cmol kg-1) Before	After	Ca (Cmol kg-1) Before	After	A1 (Cmol kg-1) Before	After	**ECEC** (Cmol kg-1) Before	After
Sole system	0	4.54	4.60	20.9	26.0	0.12	0.16	0.01	0.60	0.10	0.80	0.58	0.07	0.05	0.16	0.60	0.10	0.80	0.58
	60	4.54	4.63	20.9	2.65	0.12	0.16	0.01	0.60	0.10	0.80	0.58	0.07	0.05	0.16	0.60	0.10	0.80	0.58
	120	4.54	4.84	20.9	28.5	0.12	0.16	0.01	0.60	0.13	0.80	0.58	0.07	0.05	0.16	0.60	0.13	0.80	0.69
Sole	0	4.53	4.81	1.24	23.3	0.15	0.12	0.02	0.27	0.10	0.51	0.49	0.07	0.06	0.12	0.27	0.10	0.51	0.49
Rubber	60	.4.53	4.83	1.24	24.5	0.15	0.12	0.02	0.27	0.10	0.51	0.59	0.07	0.06	0.17	0.27	0.10	0.51	0.59
	120	4.53	4.86	1.24	27.8	0.15	0.12	0.02	0.27	0.13	0.51	0.68	0.07	0.06	0.19	0.27	0.13	0.51	0.68
Cocoyam +	0	4.54	5.07	20.9	31.9	0.12	0.12	0.02	0.60	0.13	0.80	0.54	0.07	0.05	0.13	0.60	0.13	0.80	0.54
Rubber	60	4.54	5.10	20.9	35.9	0.12	0.12	0.02	0.60	0.15	0.80	0.54	0.07	0.05	0.21	0.60	0.15	0.80	0.67
	120	4.54	5.39	20.9	39.2	0.12	0.12	0.02	0.60	0.15	0.80	0.54	0.07	0.05	0.21	0.60	0.15	0.80	0.68

NS: Not Significant at 5% level of probability

Table 2: Cocoyam yield and yield components as affected by p- fertilizers when inter cropped with mature rubber trees

Treatments Cropping system	Fertilizer (Kg/ha)	Cormel Yield (Tones/ha)	Corm Yield (Tones/ha)	Cormel Length (Cm)	Cormel Diameter (cm)
Sole Cocoyam	0	4.25	10.68	9.06	4.97
	60	3.24	9.78	9.36	4.92
	120	6.03	11.95	8.67	4.38
Cococyam + Rubber	0	2.43	4.23	6.11	4.25
	60	2.04	5.58	6.62	3.24
	120	1.28	4.02	6.01	6.03
LSD (0.05)		1.04	2.90	1.39	0.36

NS: Not Significant at 5% level of probability

Table 3: Rubber yields in rubber/cocoyam cropping system trials in Iyanomo

Treatment Cropping system	Fertilizer (kg/ha)	Mean Yeild (Tones/ha/year)	LER
Sole Rubber	0	2.8	1
	60	3.1	1
	120	3.0	1
Sole Cocoyam	0	4.25	1
	60	3.24	1
	120	6.03	1
Rubber + Cocoyam	0	3.1	1.68
	60	3.0	1.60
	120	3.3	1.31

LER: greater than one show a greater advantage of intercropping compared to sole cropping