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Studies on the Influence of Rubber Effluent and NPK Application on the Performance and Fruit Quality of Snake Tomato (*Trichosanthes cucumerina L. Haines*) in Newly Established Rubber Plantation

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Abstract:
Rubber (latex) production suffered serious drawback in the mid-1970s to late 1990s due to the withdrawal of small holder rubber growers arisen from low pricing and other agronomic challenges. A field study was carried out in 2018 and 2019 cropping season to evaluate the influence of rubber effluent and NPK fertilizer on the performance and fruit quality of snake tomato in a newly established rubber plantation in Iyanomo. The treatments involved sole snake tomato, sole rubber and their intercropped combinations with NPK (applied at 60 kg N ha-1) and rubber effluent application rates (0, 50, 60 and 70 kg N ha-1) laid out in a randomized complete block design replicated three times. Data were collected on vine length, vine girth, number of leaves, leaf area, fruit yield components, nutrient content and uptake. Results showed that NPK and rubber effluent significantly ($P<0.05$) affected growth characters and fruit yield of snake tomato positively. The fertilized plants were higher in all the characters accessed than the unfertilized plants. Sole and intercropped snake tomato fruit yield with or without treatments had similar values. Unfertilized sole and intercropped snake tomato had the lowest fruit yield. The highest fruit yield was obtained from sole and intercropped snake tomato treated with NPK (STNPK and RSNPK). The number of rotten fruits were more in the unfertilized plants compared to the fertilized plants. Nutrient content and uptake were positively influenced by soil amendments.

Keywords: Growth, fruit yield components, intercrop, NPK and rubber effluent.

INTRODUCTION

Rubber (*Hevea brasiliensis* Wild ex A. de Juss. Muell.Arg.) is a plant commercially grown in plantations for the white exudates (latex) belonging to the family Euphorbiceae. The latex is processed into crumb and sheet rubber for export. The processed latex is a raw material for the production of Elastomers. Hence, this crop serves as a mean of foreign exchange and employment (Asokan *et al.* 2000).

Despite the relevant of Rubber in the economic development of Nigeria. The country suffered a serious set-back from mid-1970s to late 1990s owing to the withdrawal of the small holder rubber grower who are the grower of this crop as constituted about 25 % of the total latex production in Nigeria (NRAN, 2014). Their withdrawal was due to discouragement resulting from low prices of processed latex in the international market and other agronomic challenges (NRAN, 2013). The agronomic challenges include the long gestation period of rubber (5 to 7years), that deprived farmers of a sustainable income (income is tied down for 5-7 years without returns) during the immature phase and the fallow land brought about by rubber spacing (Michael, 2006). At present, the price of processed latex is high in the international market but latex production is still low. As a result, the nation cannot take advantage of its developmental drive. To be able to expand Natural rubber production in Nigeria, efforts must be put in to encourage and return the smallholder's rubber growers back to production. Hence, there is the need to developed appropriate plantation management systems that will assist farmers to reduce the gestation period of rubber, reduce cost of production and ensure early returns on investment. This can be achieved through the development of an agronomic system that will intercrop rubber with other arable crops preferably snake tomato.

Snake tomato is a neglected and under-utilized crops whose importance as an alternative to the regular tomato plant has increased in recent times as a result of the scarcity and untold price hike of the regular tomato during the off season and the recent invasion by *Tuta absoluta* that ravaged the entire tomatoes farm, has directed research efforts on snake tomato as an alternative to the regular tomato.

Cost of inorganic fertilizer, its availability, adulteration and its attendant effects on the world economy has been a source of concern, hence the need for an alternative. The disposal of rubber processing effluent has been a major challenge to factory owners and a source of pollution, but its use as soil nutrient amendment will go a long way to ameliorating the challenge and waste to wealth. Hence, this study was undertaken to evaluate the influence of rubber effluent and NPK fertilizer on the performance and fruit quality of snake tomato (*Trichosanthes cucumerina* L. Haines**)** in newly established rubber plantation

MATERIALS AND METHODS

Experimental Site

This study was conducted in 2018 and 2019 cropping seasons at the Research farm of Rubber Research Institute of Nigeria (RRIN), Iyanomo (lied within the ordinates of between latitude 6^{o}00 and 7^{o}00'N and longitude 5^{o}00' and 6^{o}00'E) near Benin City, Edo State, located within the Rain Forest zone of Nigeria. The rainfall pattern is bimodal with the peaks in the month of July and September but the highest in July and a short dry spell in August. The soils of this humid forest belt are mainly ultisols and the site is classified locally as kulfo series with pH range between 4.0 and 5.5.

Experimental design and field layout

The treatments involved a combination of sole rubber and snake tomato and intercropped combination with NPK (applied at 60 kg ha^{-1}) and rubber effluent application rates (0, 50, 60 and 70 kg ha^{-1}) laid out in a randomized complete block design in three replications. For snake tomato component in the intercrop, the treatments were:

- RE1RS-Rubber Effluent at application rate of 50 Kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
- RE1ST- Rubber Effluent at application rate of 50 Kg N ha^{-1} cropped with sole snake tomato
- RE2RS- Rubber Effluent at application rate of 60 Kg N ha^{-1} cropped with rubber and Snake tomato (Intercrop)
- RE2ST- Rubber Effluent at application rate of 60 Kg N ha^{-1} cropped with sole snake tomato

- RE3RS- Rubber Effluent at application rate of 70 Kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
- RE3ST- Rubber Effluent at application rate of 60 Kg N ha^{-1} cropped with sole snake tomato
- RSC- Rubber and Snake Tomato intercrop without fertilizer treatment
- RSNPK – Rubber –snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15
- STC- Sole Snake Tomato control
- STNPK – Sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

Prior to cropping with rubber and snake tomato, soil samples were randomly collected from the experimental site at a depth of 0 - 30 cm depth using auger and bulked together to form a composite sample. The composite soil sample was air-dried and sieved through a 2 mm mesh and analyzed for its physical and chemical properties using standard laboratory procedures. After harvest, soil samples were randomly collected from each plot separately and analyzed for its post-harvest chemical properties according to methods in Mylavarapus and Kennelley (2002). The oil had pH, organic C, total N, available P, exchangeable Ca, Mg, K, Na and acidity of 5.40, 17.20 g kg^{-1}, 0.84 g kg^{-1}, 10.50 mg kg^{-1}, 0.80 cmol kg^{-1}, 0.20 cmol kg^{-1}, 0.16 cmol kg^{-1}, 0.06 cmol kg^{-1} and 0.30 cmol kg^{-1}, respectively. The proximate nutrient composition of the rubber effluent was pH 6.20, organic C 29.60 %, total N 1.10 %, P 2.03 %, Mg 0.38 %, Ca 0.49%, chemical oxygen demand, biochemical oxygen demand and total dissolved solids were 410.00, 250.00 and 760.00 mg l^{-1}, respectively.

Cultural Practices

A field measuring 26 by 60 m was cleared of the existing vegetation manually with the aid of cutlasses and hoes, the debris were packed out of the site, thereafter the field was marked out into plots measuring 3 by 7 m with a metre pathway. The rubber effluent was applied immediately to the designated plots as per treatment. The Rubber saplings were transplanted to the field, two weeks after application of effluent. The pulled budded stump (young rubber) was placed in the hole in such a way that the budded patch is just above the ground level at a spacing of 3 by 7 m which gave rise to 476 rubber stands per hectare, each plot had four rubber stands. The snake tomato seedlings of two weeks old in a poly bag nursery filled with a mixture of top soil and poultry at a ratio of 3:1 was transplanted to the designated plots, a week after planting-out of rubber sapling at a spacing of 0.5 by 0.5 m which gave rise to a total of 40000 plants per hectare. The NPK was applied to the designated plots as per treatment two weeks after transplanting of snake tomato seedlings.

Trellis was erected on the plots cropped with snake tomato seedlings immediately and directed to climb through the twine. Weeding was carried out first at six weeks after transplanting and subsequently as at when due. In due time, fruits were harvested as they ripen.

Data Collection and Analysis

Three plants within the middle row of each plot were randomly selected for Data collection on the growth (vine length, vine girth, number of leaves per plant and leaf area) of snake tomato at 50 % flowering day. At harvesting of fruits of snake tomato, data were collected on fruit length, fruit diameter, number of fruits per plant, fruit weight, number of rotten fruits per plant and fruit yield. Three harvested fruits were randomly selected from each plot and oven dried separated at 60 ^{o}C for 72 hours to a constant weight. Each dry sample was ground and passed through 0.5 mm, sieve for nutrient content (N, P, K, Ca and Mg) content determination using IITA (1979) Method. The uptake was obtained through the product of nutrient content of the fruit and weight of its dry matter.

Analysis of variance was carried out on each of the data collected after estimating the mean for two years with GENSTAT programme and means were compared using least significant different (LSD) at 0.05 level of probability.

RESULTS

Growth

The effect of NPK and rubber effluent on growth and days to first and 50 % flowering of snake tomato in sole and intercropped with rubber grown on a newly established rubber plantation are presented in Table 1. The shortest vines were observed in the sole and intercrop snake tomato (RSC and STC) plots. Snake tomato plants raised in STNPK and RSNPK plots. All fertilized plots cropped with sole and intercropped snake tomato had longer vines than snake tomato plants on unfertilized plots. Increased in rubber effluent application rate brought about increase in vine length. However, vines were longer in plants grown in plots treated with NPK than rubber effluent at 70 kg N ha^{-1}. This distribution trend was mirrored for vine girth, number of leaves per plant and leaf area.

RSC plants had most days to first flowering but not significantly different (P>0.05) from STC, RE1RS and RE1ST plants. Sole and intercrop snake tomato grown on plots treated with NPK (STNPK and RSNPK) were earliest to first flowering, this distribution trend was reported for days to 50 % flowering. The growth values accrued to first cropping were higher than in the second cropping.

Fruit Yield and Components of Snake Tomato

The fruit yield indices of snake tomato in sole and intercrop with rubber as influenced by NPK and rubber effluent cropped in a newly established rubber plantation is presented in Table 2. Sole snake tomato and intercrop treated with NPK (STNPK and RSNPK) had the longest fruits. Sole snake tomato plants in STC had the shortest fruits but similar with fruits produced from RSC, RE1RS and RE1ST. The thinnest fruits were produced from RSC but similar with STC, RE1RS and RE1ST plants. The thickest fruits were recorded in STNPK plants but not significantly different from RSNPK, RE3ST and RE3RS.

The highest number of fruits per plant was recorded in RSNPK and STNPK. The fewest number of fruits was produced from STC plot which was identical with RSC plants. Heaviest fruits were produced by plants in STNPK. Fruits of snake tomato intercropped with rubber grown in unfertilized (RSC) plots were the lightest but not significantly different from RE1RS, RE2RS, RE3Rs and STC.

Number of rotten fruits per plant was comparable among all treatments. Snake tomato plant intercropped with rubber without fertilization (RSC) had the lowest fruit yield but comparable with the fruit yield in RE1RS, RE1ST and RSC plants. The highest fruit yield was recorded in RSNPK plants which was identical with the fruit yield recorded in STNPK plants. Higher fruit yield components were observed in the first year than in the second year.

Table 1: Effect of soil amendment on the growth of snake tomato at 50 % flowering day cropped in newly established rubber plantation

Treat ment	Vine length (cm)			Stem girth (cm)			Number of leaves			Leaf area (cm²)			Days to 1st flowering					
	1st year	2nd year	Com bined	1st year	2nd year	Com bined	1st year	2nd year	Com bined	1st year	2nd year	Com bined	1st year	2nd year	Com bined	1st year	2nd year	Com bined
RE1RS	153	220.7	186.8	0.53	0.27	0.4	17	16	16.5	663.3	341	507.7	44.33	61	52.67	58.67	75.67	67.17
RE1ST	149.3	221.3	185.3	0.6	0.27	0.43	16	16	16	620.3	357	594.2	43.33	61.67	52.5	58	74	66
RE2RS	199.7	246	222.8	0.67	0.4	0.53	19.33	16.67	18	824.7	422	620.7	42	60.67	51.33	57.67	71	64.33
RE2S2	193.3	245.3	219.3	0.7	0.37	0.53	20.17	16.67	18.42	920.8	429	680.1	42	61.67	51.83	56.67	71.33	64
RE3RS	252.3	255.3	253.8	0.83	0.57	0.7	21.67	20.67	21.17	1090.7	635	842.7	42	60.33	51.17	55.67	68	61.83
RE3ST	243.7	254.7	249.2	0.87	0.57	0.72	21.67	20.67	21.17	1090	661	854.3	41.33	60.67	51	56.33	66.67	61.5
RSC	227.3	680	147.7	0.57	0.27	0.42	18.83	12.67	15.75	760	257	504	45.67	61.33	53.5	59.67	74.33	67
RSNPK	296	312	304	0.9	0.63	0.77	22	26	24	1496	1335	1389.3	40	51.67	45.83	45.67	62.67	54.17
STC	221.3	67	144.2	0.53	0.27	0.4	18.17	12.33	15.5	753.3	264	494	44.67	61	52.83	59.67	74.67	67.17
STNPK	289.7	310	299.8	0.97	0.67	0.82	22.67	25	23.83	1647.3	1302	1431	40.33	51	45.67	46	61.33	53.67
Mean	222.6	220	221.3	0.72	0.43	0.57	19.82	18.27	19.04	986.6	600	781.8	42.57	59.1	50.83	55.4	69.97	62.68
$LSD_{(0.05)}$	18.52	2.72	9.18	0.09	0.1	0.062	1.49	2.67	1.557	93.52	133.1	58.87	1.18	2.08	1.138	1.97	4.51	2.475
$LSD_{(0.05)}$ year	4.1			0.03			0.7			26.33			0.51			1.11		

Foot note

RE1RS - Rubber effluent at application rate of 50 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE1ST - Rubber effluent at application rate of 50 kg N ha^{-1} snake tomato (Sole)

RE2RS - Rubber effluent at application rate of 60 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE2ST - Rubber effluent at application rate of 60 kg N ha^{-1} snake tomato (Sole)

RE3RS - Rubber effluent at application rate of 70 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE3ST - Rubber effluent at application rate of 70 kg N ha^{-1} snake tomato (Sole)

RSC - Rubber-snake tomato intercrop without NPK/rubber effluent treatment (control)

STC - Sole snake tomato (control)

STNPK - Sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

RSNPK - Rubber-snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

Table 2: Effect of soil amendment on fruit yield and its components of snake tomato cropped in newly established rubber plantation

Treatment	Fruit length (cm)			Fruit diameter (cm)			Number of fruits per plant			Fruit weight (kg fruit^{-1})			Number of rotten fruits			Fruit yield (t ha^{-1})		
	1st	2nd year	`	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined
RE1RS	47.00	39.00	43.00	4.77	3.90	4.33	9.00	8.67	8.83	0.80	0.70	0.75	3.00	3.33	3.17	28.60	23.10	25.90
RE1ST	48.00	38.33	43.17	4.60	3.63	4.12	8.00	10.00	9.00	0.93	0.73	0.83	2.67	3.67	3.17	28.30	27.90	28.10
RE2RS	55.00	42.33	48.67	5.70	4.70	5.20	16.00	12.67	14.33	0.87	0.77	0.82	2.33	3.33	2.83	52.20	36.70	44.50
RE2S2	56.33	41.33	48.83	5.70	4.73	5.22	15.67	13.67	14.67	0.83	0.73	0.78	2.33	4.00	3.17	50.20	37.90	44.00
RE3RS	57.67	43.67	50.67	5.70	4.87	5.28	20.33	14.00	17.17	1.20	0.77	0.98	1.33	4.00	2.67	86.40	40.80	63.60
RE3ST	57.17	43.33	50.25	6.20	5.20	5.70	20.33	14.33	17.33	0.93	0.83	0.88	1.00	4.67	2.83	71.40	45.50	58.40
RSC	44.40	38.00	41.20	5.03	3.23	4.13	7.00	8.33	7.67	0.63	0.67	0.65	3.67	3.00	3.33	17.00	21.10	19.10
RSNPK	60.33	56.67	58.50	6.23	5.17	5.70	25.33	19.33	22.33	1.40	0.90	1.15	1.00	4.67	2.83	135.20	66.10	100.70
STC	43.33	37.33	40.33	5.40	3.17	4.28	6.67	7.07	7.17	1.07	0.70	0.88	3.67	3.00	3.33	27.50	20.30	23.90
STNPK	61.33	57.33	59.33	6.47	5.17	5.82	26.67	18.00	22.33	1.67	0.93	1.30	1.00	4.33	2.67	169.20	63.60	116.40
Mean	53.06	43.73	48.39	5.58	4.37	4.98	15.50	12.67	14.08	1.03	0.77	0.90	2..2 0	3.80	3.00	66.60	38.30	52.40
$LSD_{(0.05)}$	4.170	3.73	2.654	0.48	0.88	0.57 3	1.77	2.92	1.719	0.24	0.12	0.133	1.01	1.34	ns	20.230	9.820	10.550
$LSD_{(0.05)}$ year		1.190			0.26			0.77			0.06			0.36			4.720	

Foot note

RE1RS - Rubber effluent at application rate of 50 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE1ST - Rubber effluent at application rate of 50 kg N ha^{-1} snake tomato (Sole)

RE2RS - Rubber effluent at application rate of 60 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE2ST - Rubber effluent at application rate of 60 kg N ha^{-1} snake tomato (Sole)

RE3RS - Rubber effluent at application rate of 70 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE3ST - Rubber effluent at application rate of 70 kg N ha^{-1} snake tomato (Sole)

RSC - Rubber-snake tomato intercrop without NPK/rubber effluent treatment (control)

STC - Sole snake tomato (control)

STNPK - Sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

RSNPK - Rubber-snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

Nutrient Content of Snake Tomato

The nutrient content of snake tomato in sole and intercrop with rubber cropped in a newly established rubber plantation is presented in Table 3. N content ranged from 0.05 % for STC, RSC and RE1ST plants and 0.25 % for RE3RS plants. However, N content RSC, STC and RE1ST plants were at par with RE2ST. The lowest P content was observed in RE1RS plants which was similar with P content observed in STC, RSC and RE1ST plants while STNPK plants had the highest P content which were comparable with RE3RS, RE3ST and RSNPK plants. STNPK and RSC plants had the highest and lowest K concentration, respectively. STNPK plants had the highest Ca concentration while the lowest was observed in RSC and STC plants. The lowest and highest Mg were observed in RSC and RE1RS plants, respectively.

Nutrient Uptake of Snake Tomato

Results of the effect of NPK and rubber effluent on the nutrient uptake of snake tomato in sole and intercrop with rubber grown on a newly established rubber plantation is presented in Table 4. RSC plants had the lowest N uptake while the highest was observed in STNPK plants. However, P uptake was similar among treatments. The lowest K uptake was recorded in STC plants while the highest K uptake was observed in STNPK plants. Calcium (Ca) uptake was lowest and highest in STC and STNPK plants, respectively. The lowest Mg uptake was observed in STC plants but similar with Mg uptake obtained from RSC, RE3RS and RE1RS. The highest Mg content was recorded in RE3ST plants but at par with Mg uptake obtained with STNPK, RSNPK, RE2ST, RE2RS and RE1ST.

DISCUSSION

The study has showed that during the first two years of rubber cultivation, snake tomato can be cropped successfully between rubber plants spaces thereby contributing positively to national food security and ensuring land sustainability. The performance of snake tomato was not adversely affected by its intercropped with rubber as the growth and yield of the sole and intercropped snake tomato were similar. This evidenced from the fact that vine length, vine girth, number of leaves, leaf area and fruit yield exhibited similar values between intercrop and sole snake tomato.

Table 3: Effect of soil amendment on nutrient content of snake tomato fruit cropped in newly established rubber plantation

Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)			Calcium (%)			Magnesium (%)		
	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined
RE1RS	0.03	0.16	0.10	0.10	0.14	0.12	1.43	2.05	1.73	0.81	0.95	0.88	1.07	1.54	1.30
RE1ST	0.04	0.06	0.05	0.14	0.08	0.11	1.43	1.20	1.32	0.37	0.75	0.56	1.24	0.84	1.04
RE2RS	0.04	0.06	0.05	0.10	0.14	0.12	1.15	1.28	1.21	0.79	0.89	0.84	0.34	1.37	0.86
RE2ST	0.08	0.03	0.06	0.14	0.15	0.15	1.17	1.82	1.50	0.87	0.65	0.76	0.45	0.39	0.42
RE3RS	0.34	0.15	0.25	0.14	0.15	0.15	1.14	0.32	0.73	0.80	0.76	0.78	0.29	1.31	0.80
RE3ST	0.08	0.06	0.07	0.10	0.10	0.10	1.30	0.95	1.13	0.75	0.70	0.73	1.32	0.87	1.10
RSC	0.04	0.15	0.05	0.15	0.11	0.80	1.34	1.41	1.38	1.20	0.75	0.98	0.75	0.68	0.72
RSNPK	0.07	0.15	0.11	0.10	0.15	0.13	1.24	1.18	1.21	0.85	0.81	0.83	1.26	1.26	1.26
STC	0.06	0.08	0.07	0.14	0.15	0.14	1.27	1.59	1.43	0.18	0.85	0.52	1.37	1.06	1.22
STNPK	0.15	0.08	0.12	0.15	0.10	0.13	0.32	1.19	0.76	1.49	0.46	0.98	1.31	0.78	1.05
Mean	0.090	0.09	0.09	0.13	0.13	0.19	1.43	1.30	1.24	0.81	0.76	0.78	0.93	1.00	0.97
$LSD_{(0.05)}$	0.110	0.017	0.011	ns	0.015	0.028	0.006	0.017	0.011	0.006	0.055	0.029	0.006	0.017	0.11
$LSD_{(0.05)}$ year	ns			0.012			0.005			0.013			0.005		

Foot note

RE1RS - Rubber effluent at application rate of 50 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE1ST - Rubber effluent at application rate of 50 kg N ha^{-1} snake tomato (Sole)

RE2RS - Rubber effluent at application rate of 60 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE2ST - Rubber effluent at application rate of 60 kg N ha^{-1} snake tomato (Sole)

RE3RS - Rubber effluent at application rate of 70 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)

RE3ST - Rubber effluent at application rate of 70 kg N ha^{-1} snake tomato (Sole)

RSC - Rubber-snake tomato intercrop without NPK/rubber effluent treatment (control)

STC - Sole snake tomato (control)

STNPK - Sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

RSNPK - Rubber-snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

In the first year cropping in the newly established rubber plantation, the fruit yield of snake tomato plants were higher in STNPK than plants in RSNPK but in the other year their yields were comparable. This observation is in line with Esekhade *et al*. (1996) who reported that both food and horticultural crops can be intercropped with rubber during the immature period as they had no adverse effect on rubber. The competition for space, light, water and nutrients was not intense in the young rubber plantation since rubber plant requirement at this stage is minimal but will gradually increase as the plant aged. This may have accounted for the gradual reduction in growth and economic yield of snake tomato as the rubber plant aged.

Table 4: Effect of soil amendment on nutrient content of snake tomato fruit cropped in newly established rubber plantation

Treatment	Nitrogen (g kg^{-1})			Phosphorus (g kg^{-1})			Potassium (g kg^{-1})			Calcium (g kg^{-1})			Magnesium (g kg^{-1})		
	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined	1st	2nd year	Combined
RE1RS	5.43	2.96	4.19	16.40	62.16	39.30	2.96	5.43	4.20	62.16	16.40	39.30	41.44	6.65	24.00
RE1ST	4.07	2.03	3.05	11.70	54.08	32.90	2.03	4.07	3.05	54.08	11.70	32.90	88.25	40.67	64.50
RE2RS	4.03	4.40	4.21	6.20	46.20	26.20	4.40	4.03	4.22	46.21	6.20	26.20	59.04	60.74	59.90
RE2S2	4.62	2.52	3.57	11.10	73.50	42.30	2.52	4.62	3.57	73.50	11.10	42.30	58.80	67.24	63.00
RE3RS	3.67	1.00	2.33	8.70	32.66	20.70	1.00	3.67	2.33	32.66	8.70	20.70	40.67	45.92	43.30
RE3ST	4.55	2.27	3.41	9.30	54.35	31.80	2.27	4.53	3.41	54.34	9.30	31.80	54.67	94.04	74.20
RSC	4.38	2.84	3.61	2.70	70.31	36.20	2.84	4.38	3.61	70.31	2.70	36.20	54.34	10.36	38.80
RSNPK	5.68	4.13	4.90	1.50	65.10	33.30	4.13	5.68	4.91	65.10	1.50	33.30	67.24	34.58	64.30
STC	5.03	4.28	4.65	1.50	13.80	7.60	4.28	5.04	4.66	13.00	1.50	7.60	94.04	1.44	33.00
STNPK	4.96	2.47	3.71	9.50	88.20	48.90	2.47	4.96	3.72	88.20	9.50	48.90	24.66	59.04	62.60
Mean	4.64	2.89	3.77	7.80	56.04	31.90	2.89	4.64	3.77	56.04	7.80	31.90	66.15	46.07	52.80
$LSD_{(0.05)}$	0.200	0.049	0.021	0.012	0.110	ns	0.120	0.006	0.029	0.009	0.640	0.013	0.006	0.500	22.72
$LSD_{(0.05)}$ year	0.013			0.005			0.130			0.006			0.005		

Foot note
- RE1RS - Rubber effluent at application rate of 50 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
- RE1ST - Rubber effluent at application rate of 50 kg N ha^{-1} snake tomato (Sole)
- RE2RS - Rubber effluent at application rate of 60 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
- RE2ST - Rubber effluent at application rate of 60 kg N ha^{-1} snake tomato (Sole)
- RE3RS - Rubber effluent at application rate of 70 kg N ha^{-1} cropped with rubber and snake tomato (Intercrop)
- RE3ST - Rubber effluent at application rate of 70 kg N ha^{-1} snake tomato (Sole)
- RSC - Rubber-snake tomato intercrop without NPK/rubber effluent treatment (control)
- STC - Sole snake tomato (control)
- STNPK - Sole snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15
- RSNPK - Rubber-snake tomato treated with 60 kg N ha^{-1} of NPK 15:15:15

The soils of the experimental site were strongly acidic with values lower than critical level for the availability of some essential nutrients. This implied that the soil had low fertility status. Law-Ogbomo and Osaigbovo (2018) reported that most Nigerian soils are of low in native fertility owing to the highly weathered soils coupled with leaching and continuous cropping. Soil fertility is a very important factor in soil productivity in relation to nutrient and yield (Erhabor, 2005).

Plants need supply of appropriate proportionate essential nutrients from the soil for optimum growth, development and yield. Low soil fertility status without adequate soil nutrient supplementation will result in growth and yield depression due to nutrient deficiencies (Law-Ogbomo *et al*., 2020). From the the analysis of the rubber effluent, it was found to be moderately acidic and contained N, P, K and Ca in appreciable quantity. The effluent has high concentration of organic carbon, combined oxygen demand and biochemical oxygen demand at safe level. This finding is in agreement with Orhue *et al*. (2007) who reported highly significant amount of total suspended and dissolved solids, phosphate and total N in rubber effluent. Orhue and Osaigbovo, (2013) reported that rubber effluent had great potential as organic fertilizer and could be beneficial to arable crops without additional cost as effluent are waste product of rubber processing factories and its disposal has been a major concern to rubber processing factory owners. This is an indication that rubber effluent which ought to be waste and pollutant to the environment can be made to be an avenue for wealth creation through its conversion to organic fertilizer.

Days to first and fifty percent flowering were earlier in NPK and rubber effluent at higher application level treated plants. However, NPK treated plants were earliness to first and fifty percent flowering than rubber effluent and untreated plants. The fertilized plants were earlier to flowering probably due to the enhancement of their vegetative phase through the stimulating effect of the readily available nutrients on photosynthetic processes leading to early flower initiation. The early flowering was advantageous to plants fertilized with NPK and rubber effluent applied at higher rate as it resulted in higher yield.

The high snake tomato yield with longer, heavier and higher number of fruits per plants accrued to plants treated with soil amendment is clear evidence that rubber effluent and NPK enhanced yield positively. This observation is in agreement with Mbonu and Arifalo (2016) who reported that, the use of readily available fertilizer enhances the yield of the plant. In this present study, yield was most enhanced with NPK. Snake tomato plant treated with rubber effluent applied at 50 Kg N ha^{-1} had similar yield with plants without fertilizer treatment. This implies that rubber effluent application only enhanced fruit yield at higher application rate.

The reduction in fruit yield of snake tomato observed in plants grown on unfertilized plots could have arisen from insufficient nutrient uptake as the plant have to rely on nutrients from the soil which have been found to be less than the critical level in some essential plant nutrients. Apart from the nutrient being low, there could be a problem of availability of phosphorus, calcium and magnesium to the plant since pH was less than 5.50 indicating strong acidity. Plants grown on plots without fertilizer application had shorter and thinner vines with lower number of leaves and leaf area leading to reduction in fruit yield and components. Lower field yield could be due to inadequate production of assimilates owing to low nutrients availability to plants. This is an indication that growth and yield of snake tomato depends on residual soil nutrients.

The higher yield obtained from plants treated with NPK and higher rate of rubber effluent is a reflection of the application of fertilizer to the soil through improved supply of nutrients to plants leading to better utilization of carbon and consequent synthesis of assimilates. Adequate nutrient availability has been indicated to be useful to the growth and yield of snake tomato. This clearly demonstrated the benefit of the application of soil amendments. The application of soil amendment boosted the enhancement of vine length, vine girth, number of leaves and leaf area leading to the production of abundant assimilates which resulted in higher fruit yield.

The study demonstrated that intercropping rubber plant with snake tomato had no adverse effect on nutrient content and uptake of snake tomato. This was evidenced from the comparable values obtained between the sole and intercrop snake tomato. However, in the unfertilized plots, the intercrop snake tomato plants were relatively poor in nutrient content and uptake compared to the fertilized plots. This implies that in nutrient stress situation, competition for available nutrients will intensify giving rise to poorer quality of intercrop snake tomato yield.

CONCLUSION AND RECOMMENDATION

Based on the findings from this study, snake the study shows that intercropping rubber plant with snake tomato was desirable as the inter-plant competition was not intense. It ensures that farmers start reaping fruits from the enterprise from the first year. Fertilizer application increased the growth and fruit yield of snake tomato. Nutrient content and uptake by snake tomato were enhanced through fertilizer application. There were growth and yield disparity between NPK and rubber effluent treated plants, however, the application of rubber effluent at 70 kg N ha^{-1} showed promising. NPK should be applied at 60 Kg N ha^{-1} (400 Kg NPK ha^{-1}) to increase fruit yield performance and fruit quality of snake tomato.

tomato intercropping with rubber should be supplemented with fertilizer application to improve the fertility of the soil to sustain soil and higher growth of rubber and yield of snake tomato.

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