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Influence of Rubber Effluent and NPK Fertilizer on the Performance and Fruit Quality of Snake Tomato (*Trichosanthes cucumerina* L. Haines) in a Three and Four Years Old (An Existing) Rubber Plantation

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Small holder rubber farmer that account for over 75% of rubber production in Nigeria has withdrawn from production as a result of income gap created by the long gestation period of rubber amidst other agronomic challenges, hence the need to create an agronomic system that will incorporate other compactable short duration to generate additional and early source of income and take care of other agronomic challenges. An experiment was conducted in 2018 and 2019 cropping seasons to evaluate the influence of rubber effluent and NPK fertilizer on the performance and fruit quality of snake tomato in a three and four year old (an existing) rubber plantation. The treatments include sole rubber, sole snake tomato and their intercrop combinations with rubber effluent and NPK laid out in randomized complete block design replicated thrice. Data were collected on vine length, vine girth, number of leaves, leaf area, fruit yield and its components, nutrient content and uptake. Growth parameters measured increased with increase in rubber effluent application however NPK fertilized plants were superior to rubber effluent treated plant at increased dosage as there was no marked difference between plants treated with effluent at 70kgN^{-1} rubber effluent and NPK treated plants, it was also observed that the fourth year plant were higher than the third year. Nutrient content was observed to increase with fertilizer application as non fertilized had the lowest nutrient content, the least uptake was observed in the non fertilized plants.

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1. INTRODUCTION

Rubber (*Hevea brasiliensis* Wild ex A. de Juss. Muell.Arg.) belong to the family Euphorbiceae, it is commercially grown in plantations for the white exudates (latex) which is commonly referred to as white gold [1,2]. There are about twenty species that are known to produce latex; of these about twelve belong to the Hevea genus and only *Hevea brasiliensis* is economically exploited [1,3]. Rubber is very significant in world's industrialization as expressly emphasized in the production of Elastomers (materials that are made of polymers or rubber), the use of which is indispensable in land, space, and water technologies [4,2] (Jacob, 2006). It is also a major means of employment, especially in engaging the restive youths of the Niger Delta region [5,6,7]. The small holder rubber farmers are the highest contributor to the total rubber production in the world (they contribute about 75% of total rubber production) compared to estate owned (production from estate) [8,6,9,10]. The withdrawal of these small holder rubber farmers from production led to a drastic set back in rubber production in Nigeria mainly due to low prices of rubber in the international market and other agronomic challenges [11,10,12]. Most serious among these agronomic challenges are, 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 [13,10]. To be able to return these small holder rubber farmers back to production in order to achieve a feat in rubber production, there is the need to put up appropriate plantation management system that can help them reduce the gestation period of rubber, reduce cost of production and ensure early returns on investment. One way to achieve these goals is the development of an agronomic system that will intercrop rubber with other arable crops.

The scarcity and untold price hike that occur annually as a result of the off season of the tomato plant and recent invasion by *Tuta absoluta* that ravaged the entire tomato farm directed research efforts to looking for an alternative to the regular tomato. Snake tomato is a neglected and under utilised crop and its cultivation and use as an alternative to the regular tomato is attracting global interest [14].

The use of inorganic fertilizer in crop production has its disadvantages inspite of the numerous advantages accrued to it, among these disadvantages are high cost of purchase, unavailability, residual effects, adulteration etc, these disadvantages has directed research attention to looking for an alternative. Research have shown that effluent contain major plant nutrients which can improve the nutrient status and boost plant growth and development [15,16,17,18]. Its disposal has being a source of concern to rubber factory owners and environmentalist. Its use as soil amendments will go a long way in the reduction of the cost of rubber production, improving soil fertility for the benefit of the crop and also taking care of issues of water pollution raised by environmentalist and the problem of disposal posed to rubber processing factories [19,20,21]. Hence, this study seeks to look at the influence of rubber effluent and NPK fertilizer on the performance and fruit quality of snake tomato (*Trichosanthes cucumerina* l. haines) grown in a three and four years existing rubber plantation.

2. MATERIALS AND METHODS

2.1 Experimental Site

This study was conducted in 2018 and 2019 cropping seasons at the Research farm of Rubber Research Institute of Nigeria (RRIN), Iyanomo near Benin City, Edo State, which lies within the Rain Forest zone of Nigeria. The study area falls between latitude 6º00 and 7º00′N and longitude 5º00′ and 6º00′E. 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.

2.2 Experimental Design and Field Layout

The treatments involved a combination of sole and intercropped combination with NPK and rubber effluent application rates 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 control.

STC- Sole Snake Tomato control.

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

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

2.3 Soil Analysis

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 [22]. Laboratory analysis of the soil showed a pH of 5.40, organic carbon 17.20 gkg^{-1}, total nitrogen 0.84 g kg^{-1}, available phosphorus 10:00 mg kg^{-1}, exchangeable Ca, Mg, K, Na, and acidity were 0.80, 0.20, 0.16, 0.06 and 0.30Cmol kg^{-1}. The soil was also texturally sandy loam.

2.4 Rubber Effluent Analysis

Rubber effluent was analyzed before application using standard laboratory methods and the result showed that rubber effluent had a pH of 6.20 with organic carbon of 29.60gkg^{-1}, total nitrogen of 1.10%, phosphorus 2.30%, magnesium 0.38%, calcium 0.49%, sodium 0.04%, zinc 0.05%, copper 0.02%, maganese 0.08%, iron 0.10%, chemical oxygen demand, biochemical oxygen demand and total dissolved solids were 410.00, 250.00 and 760.00 mol^{-1}.

2.5 Cultural Practices

A three year old rubber plantation measuring 26 by 60 m was weeded manually with the aid of cutlasses and hoes, the debris were packed out of the plantation, thereafter the plantation was marked out into plots measuring 3 by 7 m with four rubber stand within each plot, and a meter pathway. The rubber effluent was applied immediately to the designated plots as per treatment. . The snake tomato seeds were sown in a poly bag nursery filled with a mixture of top soil and poultry manure at a ratio of 3:1 for two weeks, thereafter the seedlings were transplanted to the designated plots 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 were erected on the plots immediately after transplanting and the seedlings were directed to climb through the twine. Weeding was carried out first at six weeks after transplanting and subsequently as at when due. This whole process was repeated the next year for the four year old plantation experiment.

2.6 Data Collection

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 two weeks interval 4, 6, 8 and 10 WAT. 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, fruit yield, nutrient content and nutrient uptake.

Vine length was measured using a tape rule from the base of the plant to the tip of the vine of all the sampled plants and average computed and calibrated in cm. Vine girth was measured with the aid of a vernier caliper and calibrated in cm. Number of leaves was obtained by counting all fully expanded leaves of all sampled plants and average computed to obtain the number of leaves per plant. Leaf area was obtained through the use of the leaf area meter. Number of days to flowering was determined by counting the number of days from the day of transplanting to the day of onset and 50% flowering. Fruit diameter was determined by the use of a vernier caliper.

Fruit length was determined by measuring fruits of sampled plants using tape rule calibrated in cm. Number of fruits per plant was obtained by counting all the harvested fruits of all sampled plants divided by three to arrive at the number of fruits per plant. Fruit weight per fruit was obtained through the summation of all the harvested fruits from the sampled plants divided by the number of fruits to obtained the fruit weight calibrated in kg. The number of rotten fruits per plant was estimated by counting the number of infested/aborted/withered/spoilt fruits of all the sampled plants divided by the number of sampled plants. From fruit weight, fruit yield was estimated thus:

$$\text{Fruit yield} = \frac{\text{Fruit weight}}{\text{Ground area}} \times \frac{10000}{1000}\ \text{t ha}^{-1}$$

2.7 Data Analysis

Data collected were subjected to analysis of variance using GENSTAT statistical package twelfth edition. Means were separated using least significant difference (LSD) at 0.05 level of probability.

3. RESULTS

3.1 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 3 and 4 years old rubber plantation is shown in Table 1.

Vine length increased with increasing rubber effluent application rate. However, NPK was superior to rubber effluent in enhancing vine length. RE1RS had the shortest vines in the 4th year experiment. Vine girth varied significantly among treatments throughout the sampling periods, plants in RSC and STC had the thinnest stems but identical with plants in RE1RS in the 3rd year experiment. In the 4th year experiment, plants in RSC and STC stem girth values were identical with plants in RE1RS RE1ST and RE2ST. Plants in STNPK had the thickest stems in both experiments, however, STNPK and RSNPK plants had identical stem girth values in the 4th year experiment. Stem girth of the 3rd year experimental plants were thicker than those of the 4th year experimental plants. Stem girth increased with increasing effluent application rate. However, NPK was superior to the highest application level of effluent. Number of leaves significantly ($p<0.05$) vary among treatments, plants in RSC and STC had the fewest number of leaves while RSNPK plants had the highest number of leaves in the 3rd year experiment. In the 4th year experiment, the fewest number of leaves was recorded in plants in RE1RS, RE1ST and STC. The highest number of leaves was observed in plants in STNPK which was identical with plants in RSNPK. more leaves were produced in the 4th year experiment than in the 3rd year experiment. There was increase in the number of leaves as the rubber effluent application rate increased up to the highest rate. However, the highest level of effluent had lower number of leaves than NPK treated plants. The leaf area of snake tomato in sole and intercrop with rubber cropped in the 3rd and 4th year old rubber plantation was influenced by NPK and rubber effluent, In the 3rd year experiment, plants in RSNPK had the smallest leaf area which was similar with other treatments except RE2RS and RE3ST plants which had the highest leaf area. In the 4th year experiment, plants in RE1RS had the smallest leaf area which was not significantly different from plants in RE1ST, RE2RS, RE2ST, STC and RSC. The highest leaf area was recorded in STNPK plants. Plants in STNPK had the highest leaf area which was similar with the leaf area observed in RE3RS and RSNPK plants. The 4th year experiment had plants with higher leaf area than those in the 3rd year experiment. Leaf area was larger in the 4th year experiment than in the 3rd year experiment. Leaf area increased with increasing rubber effluent application rate but the leaf area values accrued to the highest effluent application rate was smaller than those accrued to NPK treated plants. Days to flower initiation and 50% flowering were significantly influenced by NPK and rubber effluent at 0.05 level of probability. Earliest to first flowering was recorded in STNPK and RSNPK plants while the latest days to first flowering was recorded in plants in RSC which was identical with RE1RS, RE1ST and STC plants in the 3rd year experiment. In the 4th.year experiment, the latest plants to first flowering were recorded in RE1ST and RE2ST which were identical with all other treatments except plants in RSNPK and STNPK which were earliest to first flowering. Plants in STNPK were identical with RSNPK and RE3ST in the 3rdyear experiment.

The latest to 50% flowering was recorded in RSC, STC, RE1RS and RE1ST plants in both experiments, Plants in the 3rd year experiment were earlier to 50% flowering than the 4th year experimental plants. Rubber effluent influenced days to first and 50% flowering positively as the days to first and 50% flowering decreased with increasing effluent application rate. However, the days to first and 50% flowering were earlier in NPK treated plants than RE3RS and RE3ST.

3.2 Fruit Yield and Components of Snake Tomato

The results of the effects of NPK and rubber effluent on fruit yield and yield components of snake tomato in sole and intercrop with rubber in a 3 and 4 years old rubber plantation is shown in Table 2.

The longest fruits were observed in STNPK and RSNPK plants in both experiments, Plants in STC, RSC and RE1ST had the shortest fruits in 3rd and 4th year experiment, and fruits were longer in the 4th year experiment than in the 3rd year experiment. This distribution pattern of the 4th year experiment for fruit length was repeated for the fruit diameter. Fewest numbers of fruits per plant were produced by plants in RSC and RE1RS which was comparable with the number of fruits produced by plants in STC, RE1ST, RE2RS and RE3ST in the 3rd year experiment. The highest number of fruits per plant was produced by plants in RSNPK which was comparable with STNPK, while plants in STC had the fewest number of fruits per plant which were comparable with RSC, RE1ST and RE1RS. More fruits per plant were produced in the 4th year experiment than in the 3rd year experiment. Increase in rubber effluent application rate brought increase in the number of fruits per plant up to the highest rate which was lower than snake tomato treated with NPK (RSNPK and STNPK). Fruits were lightest in STC plants which was not significantly different from other treatments except RSNPK STNPK and RE1RS which had the heaviest fruits in the 3rd year experiment. Fruits were heavier in the 4th experiment than in the 3rd experiment. The number of rotten fruits per plant was more with fertilized plants than untreated plants. Plants in STC had the lowest number of rotten fruits per plant in both experiments and in the combined analysis. However, in the 3rd year experiment, rotten fruits in STC plants were comparable with RSC, RE2RS and RE2ST plants. 4th year experiment, rotten fruits in STC plants were identical with all other treatments except RE3ST which had the highest number of rotten fruits. Plants in STC had the highest number of rotten fruits per plant which were identical with RSC, RE2ST and RE2RS plants. Most rotten fruits were recorded in RSNPK plants which were comparable with STNPK, RE3ST and RE3RS in both experiments.

RSNPK plants had the highest fruit yield which was similar with plants in STNPK. Unfertilized plants (STC and RSC) had the lowest fruit yield. However, in the 3rd year experiment, unfertilized plants were similar with RE1RS, RE1ST and RE2ST, Fruit yield was higher in the 4th year experiment than in the 3rd year experiment. Fruit yield increased with increasing rate of rubber effluent application and peak at the highest rate of application. The fruit of the highest effluent application rate (RE3RS and RE3ST) was inferior to NPK treated plants (RSNPK and STNPK).

3.3 Nutrient Content of Snake Tomato

The nutrient content of snake tomato in sole and intercrop with rubber as influenced by NPK and rubber effluent cropped in an existing rubber plantation is shown in Table 3. N content was comparable among treatments in both experiments. In the combined analysis, plants in RSC had the lowest N content which was identical with STC plants. Plants in RE2ST had the highest N content.

Phosphorus (P) content was lowest in RSC and STC and highest in RE2ST in the 3rd year experiment. In the 4th year experiment and in the combined analysis, RE1ST had the highest P content. All other treatments had identical values and were significantly lower than RE1ST.

Potassium (K) content was similar among treatments in the 3rd year experiment. In the 4th year experiment, the lowest and highest K content was recorded in RSC and RSNPK plant, respectively. In the combined analysis, plant in RSC had the lowest K content while highest K content was recorded in RE2RS and STNPK plants, respectively.

Calcium (Ca) concentration was highest in RE2ST and lowest in RSC and STC in the 3rd year experiment. In the 4th year experiment, Ca content was highest in RE2RS which was comparable with RE2ST while the lowest was recorded in RSC. This distribution trend was repeated when both experiments were pooled together.

Table 1. Effect of soil amendment on vegetative characters and days to first and 50% flowering of snake tomato cropped in an existing rubber plantation

Treatment	Plant height (cm)		Stem girth (cm)		Number of leaves		Leaf area (cm^2)		Days to 1st flowering		Days to 50 % flowering	
	3rd	4th year	3rd	4th year	3rd	4th year	3rd	4th year	3rd	4th year	3rd	4th year
REIRS	178.00	171.33	0.43	0.43	3rd	4th year	2383.00	3642.00	61.33	61.00	72.67	75.67
RE1ST	181.67	179.67	0.47	0.40	20.33	29.67	2600.00	3988.00	60.67	61.67	71.33	74.67
RE2RS	203.00	203.00	0.53	0.53	21.67	32.00	3464.00	5002.00	59.67	60.67	68.67	70.67
RE2ST	204.00	204.00	0.50	0.47	24.67	33.67	3533.00	5315.00	59.67	61.67	68.33	71.00
RE3RS	207.00	207.00	0.57	0.53	25.00	35.33	4812.00	5893.00	58.00	60.33	63.67	67.33
RE3ST	219.33	219.33	0.57	0.53	30.33	35.33	4412.00	6718.00	58.33	60.67	63.00	66.67
RSC	176.33	176.33	0.40	0.37	28.67	40.00	4498.00	4048.00	62.67	61.33	73.67	74.00
RSNPK	242.67	242.67	0.80	0.80	19.33	33.00	2369.00	8063.00	54.00	51.67	60.33	63.00
STC	175.33	178.33	0.40	0.37	35.67	45.00	5807.00	3854.00	61.67	61.00	74.67	74.67
STNPK	247.33	247.33	0.87	0.87	19.33	31.33	3763.00	8577.00	53.00	51.00	59.67	61.33
$LSD_{(0.05)}$	203.77	202.90	0.55	0.53	34.33	48.00	5864.00	5510.00	58.90	59.10	67.60	69.90

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 NPK and rubber effluent on fruit yield and its components of snake tomato cropped in an existing 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})		
	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined
RE1RS	38.00	39.33	38.67	3.10	3.97	3.53	9.33	8.67	9.00	0.77	0.73	0.75	3.67	3.33	3.50	27.30	24.10	25.70
RE1ST	37.33	38.00	37.67	3.23	3.67	3.45	10.00	10.33	10.17	0.73	0.73	0.73	3.67	3.67	3.67	28.07	28.83	28.45
RE2RS	38.33	42.67	40.50	3.50	4.70	4.10	11.00	12.67	11.83	0.70	0.77	0.73	3.00	3.33	3.17	29.57	36.70	33.13
RE2ST	37.67	41.00	39.33	3.43	4.73	4.08	11.67	13.67	12.67	0.73	0.70	0.72	3.33	4.00	3.67	32.40	36.33	34.37
RE3RS	39.00	43.67	41.33	3.60	5.00	4.30	10.67	14.00	12.33	0.73	0.80	0.77	4.00	4.00	4.00	29.97	42.27	36.12
RE3ST	38.33	43.33	40.83	3.57	5.13	4.35	12.00	14.33	13.17	0.73	0.83	0.78	4.00	4.67	4.33	33.27	45.47	39.37
RSC	36.00	38.00	37.00	3.00	3.23	3.11	9.33	8.33	8.83	0.63	0.67	0.65	2.67	3.00	2.83	22.63	21.00	21.87
RSNPK	47.33	58.00	52.67	3.73	5.13	4.43	13.33	19.33	16.33	0.87	0.90	0.88	4.67	4.67	4.67	44.03	66.07	55.05
STC	36.33	36.67	36.50	3.20	3.17	3.18	9.67	7.67	8.67	0.63	0.70	0.67	2.00	3.00	2.50	23.10	20.20	21.65
STNPK	48.33	57.00	52.67	3.67	5.13	4.40	12.33	18.33	15.33	0.83	0.93	0.88	4.00	4.33	4.17	39.07	64.73	51.90
Mean	39.67	43.77	41.72	3.40	4.39	3.90	10.93	12.73	11.83	0.74	0.78	0.76	3.50	3.80	3.65	30.94	38.58	34.76
$LSD_{(0.05)TRT}$	1.647	3.531	2.052	2.501	0.833	0.513	2.005	2.674	1.91	0.127	0.120	0.086	1.325	1.341	1.073	8.036	9.051	6.100
$LSD_{(0.05)}$ year	0.918			0.229			0.854			0.0385			0.480			2.728		

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 3. Effect of NPK and rubber effluent on nutrient content of snake tomato fruit cropped in an existing rubber plantation

Treatment	Nitrogen (%)			Phosphorus (%)			Potassium (%)			Calcium (%)			Magnesium (%)		
	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined
RE1RS	0.08	0.04	0.06	0.11	0.10	0.11	1.43	1.20	1.32	0.75	0.68	0.72	1.32	1.10	1.21
RE1ST	0.16	0.07	0.12	0.14	1.50	0.82	1.30	1.34	1.32	0.92	0.67	0.80	1.53	0.80	1.17
RE2RS	0.08	0.15	0.12	0.14	0.16	0.15	1.59	1.23	1.41	0.89	0.95	0.92	1.06	0.80	0.94
RE2ST	0.15	0.14	0.15	0.16	0.10	0.13	1.19	1.24	1.22	0.95	0.90	0.93	1.24	17.90	9.57
RE3RS	0.14	0.06	0.10	0.13	0.16	0.15	1.23	1.80	1.52	0.68	0.81	0.75	0.83	0.90	0.87
RE3ST	0.16	0.06	0.11	0.14	0.13	0.14	1.60	0.95	1.28	0.86	0.85	0.86	1.26	1.20	1.23
RSC	0.04	0.03	0.04	0.10	0.08	0.09	1.17	0.42	0.80	0.46	0.48	0.47	0.78	0.40	0.59
RSNPK	0.08	0.07	0.08	0.14	0.15	0.15	1.17	1.82	1.50	0.89	0.74	0.82	0.82	0.80	0.81
STC	0.06	0.04	0.05	0.10	0.10	0.10	1.14	1.14	1.14	0.46	0.63	0.55	0.45	0.60	0.53
STNPK	0.08	0.14	0.11	0.15	0.40	0.28	1.80	1.24	1.52	0.75	0.65	0.70	1.06	0.80	0.93
Mean	0.10	0.07	0.09	0.13	0.29	0.21	1.36	1.34	1.35	0.75	0.74	0.75	1.01	2.50	1.77
$LSD_{(0.05)TRT}$	Ns	Ns	0.012	0.006	0.281	0.134	Ns	0.005	0.012	0.006	0.079	0.012	0.306	15.670	7.545
$LSD_{(0.05)}$ year	0.005			0.060			0.005			0.005			ns		

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 4. Effect of NPK and rubber effluent on nutrient uptake of snake tomato fruit cropped in an existing rubber plantation

Treatment	Nitrogen (g kg^{-1})			Phosphorus (g kg^{-1})			Potassium (g kg^{-1})			Calcium (g kg^{-1})			Magnesium (g kg^{-1})		
	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined	3rd	4th year	Combined
RE1RS	0.07	0.04	0.06	2.89	0.07	1.48	0.04	0.95	0.50	0.95	2.19	1.92	0.64	0.87	0.76
RE1ST	0.07	0.04	0.06	1.52	0.06	0.79	0.04	0.72	0.38	0.72	1.52	1.12	1.17	1.19	1.18
RE2RS	0.07	0.04	0.06	1.53	0.07	0.80	0.04	0.84	0.44	0.84	1.53	1.19	1.17	1.19	1.13
RE2ST	0.06	0.06	0.06	2.19	0.06	1.13	0.06	1.37	0.72	1.37	2.19	1.78	0.94	1.66	1.30
RE3RS	0.06	0.04	0.05	1.52	0.06	0.79	0.03	0.72	0.50	0.47	1.52	1.10	0.86	1.19	1.03
RE3ST	0.07	0.05	0.06	2.89	0.07	1.48	0.05	1.05	0.55	1.05	2.89	1.97	0.94	1.66	1.30
RSC	0.05	0.01	0.03	1.50	0.05	0.78	0.01	0.47	0.24	1.05	1.50	0.99	0.56	0.71	0.64
RSNPK	0.07	0.07	0.04	1.52	0.08	0.80	0.05	0.98	0.52	0.47	1.52	1.25	1.35	0.54	0.95
STC	0.05	0.03	0.04	0.84	0.05	0.45	0.03	0.47	0.38	0.98	0.84	0.62	0.27	0.45	0.36
STNPK	0.07	0.04	0.05	1.62	0.07	0.84	0.04	1.47	0.76	1.37	1.62	1.55	1.03	0.87	0.95
Mean	0.06	0.04	0.05	1.80	0.06	0.93	0.04	0.95	0.50	0.95	1.80	1.38	0.89	1.02	0.95
$LSD_{(0.05)TRT}$	0.008	0.007	0.011	0.006	0.004	0.011	0.006	0.003	0.012	0.006	0.003	0.013	0.008	0.007	0.011
$LSD_{(0.05)}$ year	0.005			0.005			0.005			0.005			0.005		

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 Mg content was lowest and highest in STC and RE1ST, respectively in the 3rd year experiment. In the 4th year experiment, RSC and RE2ST had the lowest and highest Mg content, respectively. However, all other treatments except RE2ST had similar Mg content values with RE2ST. This distribution trend was also mirrored in the combined analysis.

3.4 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 cropped in an existing rubber plantation is presented in Table 4. In the 3rd year experiment, RE1RS, RE1ST, RE2RS, RE3ST, RSNPK and STNPK had identical N uptake values which were the highest. STC and RSC had the lowest N uptake values. In the 4th year experiment, the highest N uptake was observed in RE2ST and RSNPK while the lowest uptake was recorded in RSC. In the combined analysis, RE1RS, RE1ST, RE2RS, RE2ST and RE3ST had identical N uptakes which were the highest. RSC had the lowest N uptake.

Plants in STC had the lowest P uptake in the 3rd year experiment, RE3ST and RE1RS had the highest P uptake. In the 4th year experiment, RSC and STC had the lowest P uptake values while RSNPK had the highest P uptake. In the combined analysis, STC had the lowest P uptake while RE1RS and RE3ST had the highest P uptake values. In the 3rd year experiment, the K uptake ranged from 0.01 and 0.06 g kg^{-1} for RSC and RE2ST, respectively. In the 4th year experiment and in the combined analysis, the lowest and highest K uptake was recorded in RSC and STC, respectively. However, RSC and STC have similar values in the 4th year experiment.

Calcium (Ca) uptake was lowest in RE3RS and RSNPK while STNPK had the highest uptake in the 3rd year experiment. In the 4th year experiment and in the combined analysis, RE1RS had the highest Ca uptakes while STC had the lowest Ca uptake. Magnesium (Mg) uptake was lowest in STC and highest in RSNPK in the 3rd year experiment. In the 4th year experiment and in the combined analysis, STC had the lowest Mg uptake. RE3ST had the highest Mg uptake in the 4th year experiment and in the combined analysis.

4. DISCUSSION

The study has showed that snake tomato can be cropped successfully between rubber plants spaces in a three and 4 years old rubber plantation, thereby contributing positively to national food security and ensuring land sustainability. This study has showed the need to save this crop from extinction. Snake tomato was not detrimental to the growth of rubber plant since the growth and yield of the sole and intercropped snake tomato were similar as well as the rubber plant growth were not adversely affected in the intercrop apart from the leaf area. This evidenced from the fact that vine length, vine girth, number of leaves and leaf area exhibited similar values between intercrop and sole snake tomato. Fruit yield of snake tomato in sole and intercrop fertilized with NPK(SNPK and RSNPK) were not significantly different, 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. It was observed that the 4th year experiment gave a better growth and higher yield than the 3rd year experiment which was as a result of the residual effect of the fertilizer used and mulching effect of the snake tomato residue after harvest and the shading effect of the canopy, this agrees with observation by Sharifi et al. [23]. Shading restricts temperature fluctuation thereby stabilizing soil temperature and reducing evapotranspiration. 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 intercropped snake tomato yield.

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 earliest 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 [24,25]. 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 low rotten, 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. However, 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 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 which agrees with observation by Lawal [26]; Agba and Enya [27] and Eifediyi and Remison [28] all adduced increase in vegetative parameters and yield components of cucumber to the influence of applied fertilizer.

The higher nutrient content and uptake of fertilized plants was probably caused by the improved soil fertility status occasioned by the application of NPK and rubber effluent which aligns with report by Adekiya and Agbede, [29] and confirmed by findings by Adewale et al. [30] and Sanni et al. [31] that, increase in plant growth and yield as a result of application of organic manure is expected, in that manure contained and released considerable amount N and Mg for plant use during the process of mineralization and results in high content of Nitrogen and other nutrients, which indicates that high nutrient content is required for a successful crop growth and yield . The soil pH of the fertilized plot could have been improved owing to reduction in exchangeable acidity and exchangeable Ca [32,33]. The transformation of the soil reaction from the initial strongly acidic to moderately acidic probably led to improved nutrient content of the fruit through its positive influenced on the soil nutrient availability to the plants. NPK treated plants were not superior to rubber effluent treated plants in terms of nutrient content and uptake. The N content of plants fertilized with 60 Kg N ha^{-1} rubber effluent was higher than plants fertilized with NPK. This is an indication of higher protein content of the fruit associated with rubber effluent treated plant over NPK hence higher quality.

5. CONCLUSION AND RECOMMENDATION

The study shows that intercropping rubber plant with snake tomato was desirable as the inter-plant competition was not intense. It ensures income flow to farmers from the first year to offset the initial cost of investment on rubber plantation.

Fertilizer application increased the growth of snake tomato and rubber and also the yield of snake tomato. Nutrient content and uptake by snake tomato were enhanced through fertilizer application.

Based on the findings from this study, snake 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 quality and yield of snake tomato.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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