Optimization of Transplanting Densities in a Sweet Potato and Tomato Intercrop for Enhanced Land Productivity

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Abstract
This study evaluated the intercrop performance of improved sweet potato variety (UMOSPO1) with tomato (premium 150) under different organic fertilizer rates. UMOSPO3 was intercropped with tomato at different population densities (T2a-100% sweet potato, T2b-100% sweetpotato+100% tomato, T2c-100% sweetpotato+50% tomato, T2d-50% sweetpotato+100% tomato, T2e-50% sweetpotato+50% tomato), F2f – 100% tomato and fertilized with organic fertilizer at 0, 15, 30, and 45 mL in 2020 and 2021 planting seasons as 6x4 factorial arranged in a randomized complete block design and replicated three times. Data were collected on the vine length (VL), fresh tuber weight (FTW), and Land Equivalent Ratio (LER), and analysed using ANOVA and means were separated using least significant differences at 5% level of significance. the VL and FTW ranged from 102.37±2.85 (0 mL) to 144.93±2.85 (45 mL) and 8.18±0.31 g (0 mL) to 13.48±0.31 g (30 mL), and from 95.08±3.19 (T2b) to 160.25±3.19 (T2a) and 8.12±0.35 g (T2b) to 14.22±0.35 g (T2a), and the LER ranged from 1.30 (T2b) to 1.59 (T2c). The interaction between nutrients and cultivars was significant for the FTW. Organic fertilizer rate of 45 mL was best for the agronomic parameters, while 35 mL was optimal for tuber production. However, 100% sweetpotato+50% tomato had 159% higher productivity to sole crop.

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Keywords: Intercropping, Organic fertilizer, Farming system, Crop yield

Introduction

The increasing interest in sweet potato *Ipomea batata* cultivation in West Africa has been encouraged by research works of the National Root Crops Research Institute (NRCRI) Umudike and the International Institute for Tropical Agriculture (IITA) Ibadan. It is a warm season root crop widely grown in the tropics, belonging to the family convovulaceae and commonly called morning glory (Wardell, 2006) [20]. Also recognized as one of the most important domestic and industrial uses of food for both man and livestock, manufacture of starch, glucose, alcohol, leaves used as vegetables and fodder for livestock, containing Vitamins A and C, Calcium, Thiamine, Riboflavin, Protein and Carbohydrate etc. A native of Central America introduced into Africa by Spanish and Portuguese explorers. Its yield like most other crops is influenced by climatic, biological and soil factors (Ketema and Beyene, 2021) [8].

Tomato *Lycopersicon esculentum* on the other hand is an edible often red berry of the vegetable plant originated from South American with numerous varieties grown all over the World in field and green houses. They are consumed in diver's ways either raw or cooked as sauce, salads, drinks, and confectionaries (Rab *et al*., 2013) [16]. Thus, intercropping sweet potato and tomato will stabilize moisture loss, reduce the incidence of pests and diseases, increase light interception and decrease light reflection, improve the soil fertility, reduce the incidence of erosion and makes the surrounding climates more conducive for plant growth and sole cropping. Typically, ecosystem function in natural systems declines more rapidly with increasing species loss and such weight suggests that this can be corrected by intercropping (Zhang *et al*., 2024) [21]. Although considerable evidence exists for the benefits of intercropping as a practice to increase sustainable crop production intensification, wide adoption of such practices will only occur with the support of policies, institution, and markets that create the social structures and norms that influence individual farmer behavior Anitha *et al*. (2001) [2]. Cover crop mixtures have been identified as an entry point for more transformation systems of intercropping, since the planting of cover crops is relatively compatible with the current cash crop production system. Hence intercropping can contribute to sustainable intensification of industrial agricultural landscapes and play an industrial role in increasing productivity, stability and other ecosystem service, this concept of multi functionality and restoring ecosystem services calls for increasing crop diversity at their core (Ndakidemi, 2006) [13]. Realistic expectations of complementarily in annual cropping systems, thoughtful research and comprehensive reporting are key strategies to increasing intercropping adoption and aggregating knowledge of the intercropping discipline. Furthermore, recent progress with cover crops provides a template for advancing this; hence the research work involves the mixture of sweet potato and tomato intercrop using organic inputs.

The early part of agriculture was dominated by intercropping either by design or accident, but with the advent of modern agriculture i.e industrialized agriculture, green revolution etc. intercropping began to disappear from many farm owner's practices. This shift probably was driven primarily by mechanization and specialization leading to the production of large number of crops in monocultures with its exacerbating issues. Despites pressures to abandon intercropping, it has survived and flourished, because increasing interest in sustainability and environmental concerns have shifted attention back to intercropping as a means of better utilization of resources while conserving the environment (Guirado *et al*., 2021). Despite all these breakthroughs, intercropping is still an essential component of smallholder cropping systems, but in industrialized production where nutrient cycles are more externally regulated, intercropping is underutilized.

The application of organic fertilizer is a significant means to maintain the sustainable utilization of soil fertility and also an important production tool to optimize agricultural yield. Fertilization with organic fertilizer reduces the application of chemical fertilizer and protects the environment (Iqbal *et al*., 2019) [7]. The demand for fertilizer has increased significantly, in order to obtain higher yields and maintain high-intensity vegetable production. To regulate this high demand for chemical fertilizers, alternative technologies/practices like organic fertilizer are constantly being tested by researchers. The application of organic fertilizer improves the quality and yield of crops by improving photosynthetic efficiency and thereby increasing biomass (Zhang *et al*., 2020) [22]. Adekiya *et al*. (2020) [1] showed that organic fertilizer combined with nitrogen N, phosphorus (P), and potassium (K) fertilizer improved the plant growth, yield, and contents of minerals, proteins, carbohydrates, and mucilage in Abelmoschus esculentus. Thus, this study evaluated the growth and yield performance of sweetpotato intercropped with tomato under different population densities as influenced by organic fertilizers.

Materials and Methods

Area of Study: The experiment was conducted in 2020 and 2021 planting seasons at the Organic Research Farm of Southern Delta University, Ozoro located at Latitudes 5o45 N and Longitude 6o50 E, with a mean annual rainfall of between 2000-3000mm, the mean annual temperature is between 25-31 0C and a relative humidity ranging between 75-100% respectively with dry and raining season (NIMET, 2019) [15].

Land Preparation: The field experiment was carried out in two cropping seasons in a well cleared land, ploughed and harrowed before pegging and lining out on block basis.

Pre-planting Soil Analysis: The soil sample was randomly collected from the experimental plots at the depth of 0-20 cm with the aid of a tabular sampling auger. The samples were bulked together and air-dried at room temperature for five days. The air-dried samples were subsequently crushed to pass through a 2 mm sieve and analyzed for its initial physical and chemical properties. The soil physico-chemical analysis was done at the Department of Science and Laboratory Technology of the Southern Delta University, Ozoro.

Nursery of Tomato Seeds

Pre-nursery: A nursery bed was prepared with a rich top soil, well protected with a net covering from insects, snail and crawling animals at the school nursery site. Germinating seedlings were allowed to stay in the pre-nursery for two weeks before they were transferred to the main nursery site.

Nursery: Young seeding from the pre-nursery was transferred into poly bags filled with top soil at two weeks after germinating. One seedling stand was placed inside the poly bag and allowed to grow further for another two weeks to fully establish before transplanting finally to the main field.

Treatment and Experimental Design: The study was a 4 × 5 factorial experiment laid out in a randomized complete block design (RCBD). Liquid organic fertilizer application was (0, 15, 30 and 45 ml) and population density in the intercrop include;

- 100% sole crop of tomato (T1 for tomato),
- 100% sole crop of sweet potato (T1 for sweet potato),
- 50% tomato+ 50% sweet potato (T2),
- 50% tomato+100% sweet potato (T3),
- 100% tomato+ 50% sweet potato (T4) and
- 100% tomato+ 100% sweet potato (T5).

The factorial combination gave 24 treatments which were replicated three times. The experiment was done for two consecutive different seasons (2020 and 2021) and the mean collated for analysis.

Data Collection: The plant height, number of leaves, stem girth, number of branches, leaf area, fresh tuber weight (sweet potato alone), fresh fruit weight (tomato alone), weight of fresh fodder, weight of dry fodder, and the land equivalent ratio was calculated as follows; LER $=\sum_{j=1}^{m}\frac{yi}{yij}$

Where: yi is the yield of ith component from a unit area grown as intercrop and yij is the yield of ith component grown as sole crops over the same area. In brief, LER is the summation of ratios of yields of intercrop to the yield of sole crop.

Statistical Analysis: Data were analysed using analysis of variance (ANOVA) of Statistical Analysis System (SAS, 2000) and different means were separated by Least Significant Difference (LSD) at $p\leq0.05$.

Results

Physical and Chemical Properties of the Before and After Soil Use for the Study

The result of pre-trial physical and chemical analysis of the soil and compost used for the study is presented in Table 1. The textural class of the soil is sandy loam and is slightly acidic with pH of (5.45). The soil is low in total nitrogen, phosphorus and potassium. The exchangeable bases and cations were within the optimum mineral range for upland rice growth. The results of the before soil analysis showed that the phosphorus, potassium, calcium and magnesium contents were 6.20 mg/kg, 0.15, 4.40 and 2.00 cmol/kg, respectively. However, the available nitrogen in the soil was 10.95 g/kg which was higher than the N concentration in the pre-trial soil analysis used for the experiment.

Table 1. Physical and Chemical Properties of the Before and After Soil Used for the Experiment

Parameters	Values
pH (H_2O)	5.45
Organic matter (g/kg)	10
Organic carbon (g/kg)	7.5
Total nitrogen (g/kg)	0.95
Available P(mg/g)	2.45
Exchangeable bases (cmol/kg)	
K	0.25
Ca	5
Mg	2.8
Na	0.42
Extractable micronutrients (mg/kg)	
Mn	79
Fe	88.7
Cu	2.41
Zn	1.47
Physical properties (%)	
Sand	58.50
Silt	13.20
Clay	28.30
Textural class	Sandy loam

Response of Varying Population Density and Different Liquid Organic Fertilizer Application on the Growth and Yield of Sweet Potato Intercrop Grown with Tomato

Results obtained on the effect of fertilizer rates, planting population and the interaction between fertilizer rates and planting population on the vine length of sweet potato plant showed that there was a gradual increase in the vine length from 2 WAP to 8 WAP across the factors (Table 2). At 8WAP, the 45 g rate (144.93±2.85) produced the longest vine length which was significantly longer than the rest rates. Also at the 8 WAT, the longest vine length was recorded in the field planted with 100% sweet potato (160.25±2.85) which was significantly longer than the sweet potato plants in the rest planting populations. The interaction between fertilizer rate and planting population was significant in the recorded vine lengths at 8 WAP. and it ranged from 85.8 cm (SP100T100, 0 mL) to 180.3 cm (SP100, 30 mL) (Fig 1).

The number of leaves produced by the sweet potato plants increased gradually from 2 WAP to 8 WAP across the rates, planting population, and the interaction between the fertilizer rates and the planting population (Table 3). At the 8 WAP, the plot applied with 45g rate of fertilizer (72.23±1.43) produced the highest number of leaves which was significantly higher than the rest rates.

Also, the number of leaves produced by sweet potato plants planted in the field at 100% sole population (99.29±1.59) was significantly higher than the rest planting method. The interaction between fertilizer rate and planting population was significant in the recorded number of leaves at 8 WAP, and ranged from 30.3 (SP100T50, 0 ml) to 128.8 (SP50T50, 30 mL) (Fig 2).

The number of branches produced increased gradually from 2 WAT to 8 WATS across the rates, planting population, and the interaction between the fertilizer rates and the planting population (Table 4). At the 8 WAP, the plot applied with 45 g rate of fertilizer (19.70±0.77) produced the highest number of branches which was significantly higher than the rest rates. Also, the number of branches produced by sweet potato plants planted in the field containing 50% sweet potato and 100% tomatoes (20.42±0.86) was significantly higher than the rest planting population.

The leaf area produced by the sweet potato plants increased gradually from 2 WAP to 8 WAP across the rates, planting population, and the interaction between the fertilizer rates and the planting population (Table 5). At the 8 WAP, the plot applied with 45g rate of fertilizer (134.66±0.95) produced the largest leaf area which was significantly higher than the rest rates.

Also, the area of the leaves produced by sweet potato plants planted in the field at 100% sweet potato population (141.24±1.06) was significantly higher than the rest planting population. There were no significant differences in the leaves area produced from 2 WAP to 8 WAP in the interaction between fertilizer rate and the planting system, and at 8 WAP it ranged from 108.3 (SP100T100, 15 ml) to 161.3 cm (SP100, 45 ml) (Fig 3).

Table 2: Effect of fertilizer rates, planting population and the interaction between fertilizer rates and planting population on the vine length of sweet potato plant

Factors	Vine length L2WAP	VL4WAP	VL6WAP	VL8WAP
RATE				
0	17.37a	34.30d	70.13d	102.37c
15	17.83a	37.73c	73.90c	109.77c
30	18.43a	45.93b	80.40b	123.03b
45	17.90a	48.97a	84.23a	144.93a
LSD(0.05)	1.63	2.16	3.23	7.98
SE	0.58214	0.77143	1.15357	2.85
Population				
SP100	28.79a	56.08a	88.54a	160.25a
SP100T100	18.21b	39.08bc	74.63b	95.08d
SP100T50	15.13c	39.71b	73.29b	118.17b
SP50T100	11.71d	36.96c	75.83b	106.50c
SP50T50	15.58c	36.83c	73.54b	120.13b
LSD(0.05)	1.82	2.41	3.61	8.92
SE	0.65	0.86071	1.28929	3.18571
AR*POP	4.65ns	36.39ns	100.66ns	1215.23*

LSD: Least significant differences, SE: Standard error, SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Dos*Pop: Interaction between rate and population

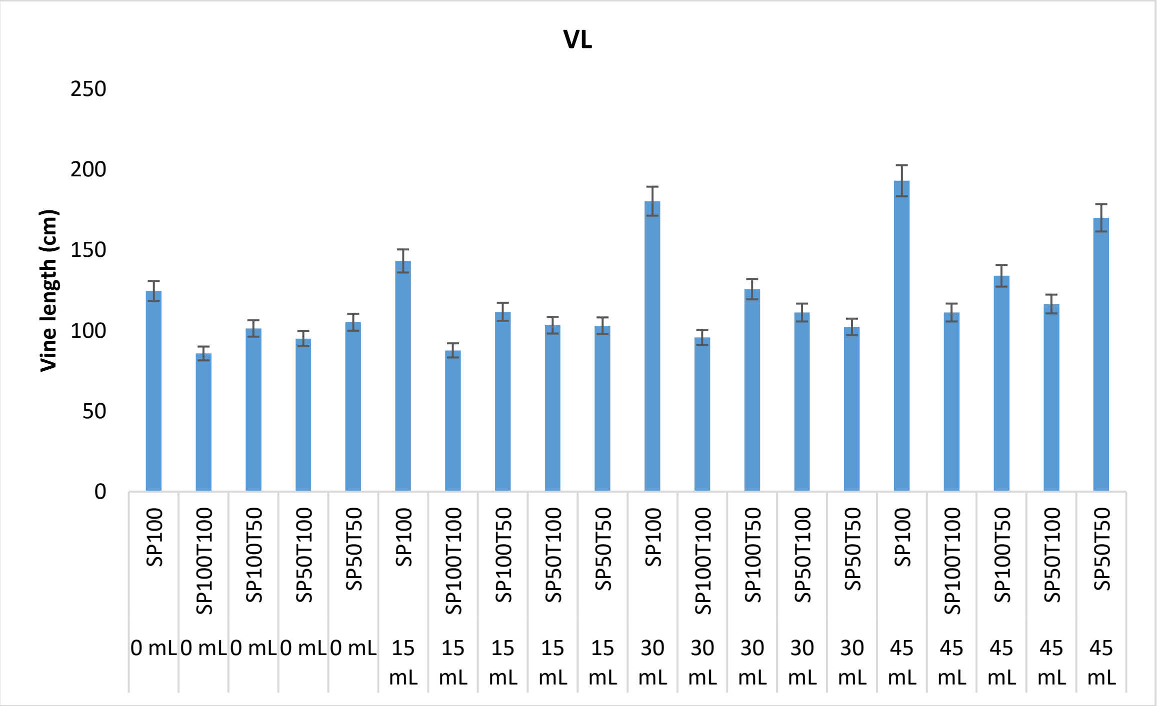

Fig 1: Interactive effect of fertilizer rates and intercrop system on the vine length of sweet potato

Keys: SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between rate and population

Table 3: Effect of fertilizer rates, planting population and the interaction between fertilizer rates and planting population on the number of leaves of sweet potato plant

Number of Leaves at weeks after Planting				
Factors	**2**	**4**	**6**	**8**
RATE				
0	4.13a	8.43d	21.57c	43.90d
15	4.30a	9.40c	22.60c	50.60c
30	4.50a	11.23c	27.73b	61.67b
45	4.27a	12.00a	31.07a	72.23a
LSD(0.05)	0.49	0.53	2.98	3.99
SE	0.175	0.18929	1.06429	1.425
Population				
SP100	6.42a	12.17b	26.63b	99.29a
SP100T100	4.13b	9.42d	22.92c	39.67d
SP100T50	3.83bc	6.67e	20.54c	37.42d
SP50T100	3.29c	10.13c	28.25ab	50.46c
SP50T50	3.83bc	12.96a	30.38a	58.67b
LSD(0.05)	0.56	0.59	3.33	4.47
SE	0.2	0.21	1.18	1.59
RATE*POP	0.28ns	6.96ns	115.25ns	889.54*

LSD: Least significant differences, SE: Standard error, SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between fertilizer rates and population.

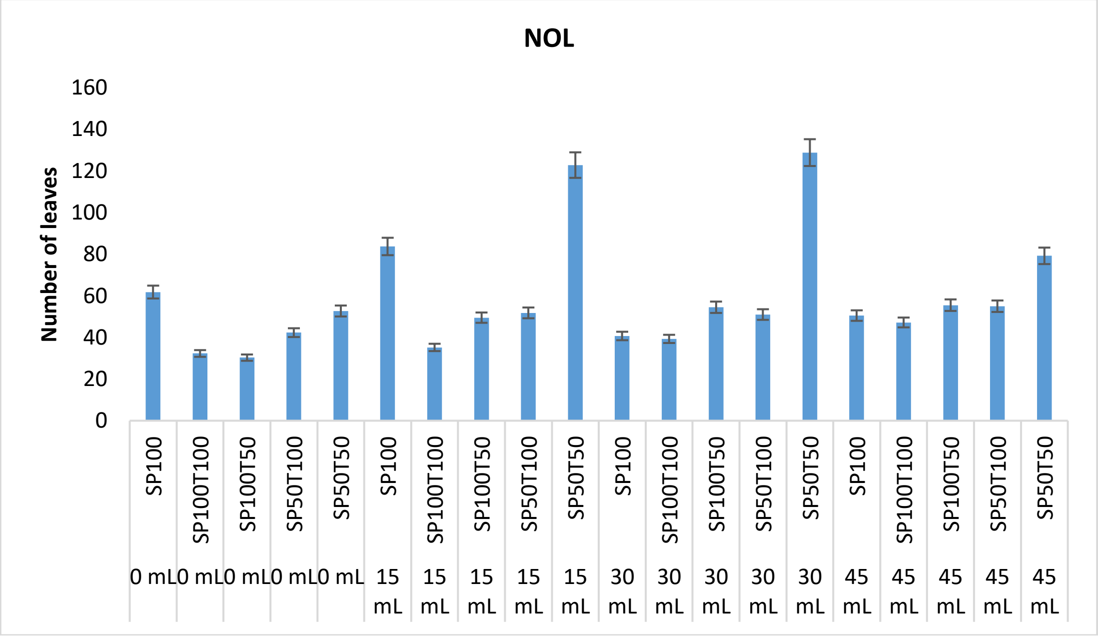

Fig 2: Interactive effect of fertilizer rates and intercrop system on the number of leaves of sweet potato

Keys: SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between fertilizer rates and population

Table 4: Effect of fertilizer rates, planting population and the interaction between fertilizer rates and planting population on the number of branches of sweet potato plant

	Plant Girth at WAP			
Factors				
RATE				
0	0.40a	2.83d	7.37c	11.93c
15	0.50a	3.33c	7.80c	13.13bc
30	0.53a	4.30b	8.57b	15.27b
45	0.53a	4.73a	9.23a	19.70a
LSD(0.05)	0.29	0.31	0.5	2.16
SE	0.10357	0.11071	0.17857	0.77143
Population				
SP100	1.00a	3.58bc	7.63c	14.67b
SP100T100	0.50b	3.71b	6.96d	10.33c
SP100T50	0.50b	3.29c	7.08cd	11.38c
SP50T100	0.29bc	4.63a	11.33a	20.42a
SP50T50	0.17c	3.79b	8.21b	18.25a
LSD(0.05)	0.33	0.35	0.56	2.41
SE	0.11	0.12	0.2	0.86
Rate*POP	0.06ns	0.57ns	1.06ns	62.22ns

LSD: Least significant differences, SE: Standard error, SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between rate and population

Table 5: Effect of fertilizer rates, planting population and the interaction between fertilizer rates and planting population on the leaf area of sweet potato plant

Leaves Arad at week after planting				
Factors	**2**	**4**	**6**	**8**
RATE				
0	62.97a	79.23b	96.73d	119.54c
15	62.30a	80.80b	100.07c	120.83c
30	63.40a	87.83a	104.27b	126.39b
45	62.83a	88.90a	107.77a	134.66a
LSD(0.05)	2.51	1.88	2.99	2.65
SE	0.89643	0.67143	1.06786	0.94643
Population				
SP100	72.21a	93.29a	111.42a	141.24a
SP100T100	60.67b	81.92c	92.96d	109.88d
SP100T50	63.00b	84.04b	100.42c	123.50c
SP50T100	55.50c	78.71d	105.08b	121.21c
SP50T50	63.00b	83.00bc	101.42c	130.92b
LSD(0.05)	2.81	2.09	3.35	2.97
SE	1	0.75	1.19	1.06
RATES*POP	11.36ns	80.16ns	101.15ns	381.33ns

LSD: Least significant differences, SE: Standard error, SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between fertilizer rate and population.

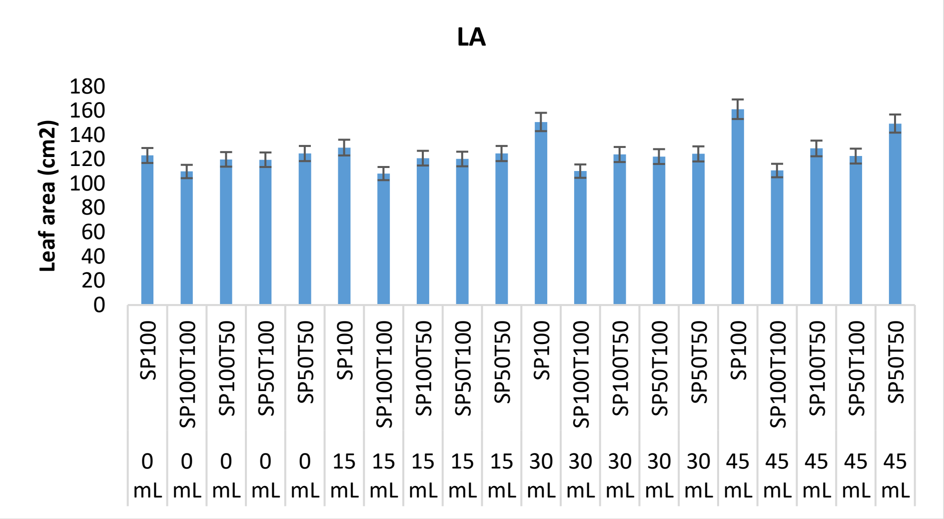

Fig 3: Interactive effect of fertilizer rates and intercrop system on the leaf area of sweet potato

Keys: SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between rate and population

The plant girth produced increased gradually from 2 WAP to 8 WAP across the rates, planting population, the interaction between the fertilizer rates and the planting population (Table 6). At the 8 WAP, the plot applied with 45g rate of fertilizer (2.52±0.04) produced the largest girth which was significantly higher than the rest rates. Also, the plant girth produced by sweet potato plants planted as 100% sole crop (2.61±0.05) was significantly higher than the rest planting population. There were no significant differences in the plant girth produced from 2 WAP to 8 WAP in the interaction between fertilizer rate and the planting population.

Table 7 shows that the FTW, WODF, WOFFH, and FTN were significant across the fertilizer rates, and the planting population, while the interaction between fertilizer rates and planting population on sweetpotato plants were significant on the WODF and WOFFH (Fig 4 and 5). The FTW produced in the 30 g rate (13.48±0.31) was significantly bigger than the rest rates. The WODF produced in 30 g rate (0.35±0.01) was statistically similar with 45 g (0.34±0.01), but was significantly heavier than the rest rates. The WOFFH produced in 30 g rate (0.87±0.01) was statistically similar with 45 g (0.85±0.01), but was significantly heavier than the rest rates. Also, the FTN produced in 30 g rate (3.23±0.14) was significantly higher than the 45 g (2.70±0.14), but was statistically similar to the rest rates.

On the planting system, the heaviest FTW (14.22±0.35), WODF (0.54±0.01), and WOFF (1.06±0.01) produced were recorded in the sweet potato planted as 100% sole crop which was significantly heavier than the rest planting population. However, the plots containing 100% sweet potato and 50% tomato produced the heaviest FTN (3.94±0.16) which was significantly heavier than the rest planting populations. The interaction between rates and the planting population was significant on the WODF and WOFFH, respectively, and the FTW ranged from 6.2 (SP100T100, 0 mL) to 18.5 (SP100, 30 mL), while the WOFFH ranged from 0.1 (SP100T100, 0 mL) to 0.7 (SP100, 30 mL). The interaction between rates and the planting population was significant on the WODF and WOFFH, respectively, and the WODF ranged from 6.2t/ha (SP100T100, 0 mL) to 18.5 t/ha(SP100, 30 mL), while the WOFFH ranged from 0.1 (SP100T100, 0 mL) to 0.7 (SP100, 30 mL).

The land equivalent ratio of the intercrops obtained ranges 1.30 (SP100T100) to 1.59 (SP100T50) with corresponding yield advantage of 30.4% to 59.3% (Table 8).

Table 6: Effect of fertilizer rates, planting population and the interaction between fertilizer rates and planting population on the plant girth of sweet potato plant

Factors	Plant Girth at week after Planting			
RATE				
0	0.34a	0.51d	0.97d	1.91d
15	0.34a	0.56c	1.09c	2.06c
30	0.35a	0.68b	1.32b	2.25b
45	0.35a	0.72a	1.46a	2.52a
LSD(0.05)	0.02	0.03	0.1	0.12
SE	0.00714	0.01071	0.03571	0.04286
Population				
SP100	0.45a	0.78a	1.53a	2.61a
SP100T100	0.33b	0.57c	1.12b	1.88c
SP100T50	0.32bc	0.58bc	1.15b	2.19b
SP50T100	0.30c	0.61b	1.12b	2.09b
SP50T50	0.32bc	0.56c	1.13b	2.16b
LSD(0.05)	0.03	0.04	0.12	0.13
SE	0.01	0.01	0.04	0.05
Rate*POP	0.001ns	0.01ns	0.11ns	0.12ns

LSD: Least significant differences, SE: Standard error, SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between rate and population

Table 7: Effects of fertilizer rates, planting population and the interaction between fertilizer rates and planting population on the yield parameters of sweet potato

Factors	FTW	WODF	WOFFH	FTN (t/ha)
RATE				
0	8.18d	0.24c	0.67c	2.87ab
15	10.04c	0.27b	0.76b	3.13a
30	13.48a	0.35a	0.87a	3.23a
45	12.43b	0.34a	0.85a	2.70b
LSD(0.05)	0.88	0.02	0.03	0.39
SE	0.31	0.01	0.01	0.14
Population				
SP100	14.22a	0.54a	1.06a	3.33b
SP100T100	8.12e	0.25bc	0.63d	2.13d
SP100T50	12.28b	0.26b	0.79b	3.94a
SP50T100	9.53d	0.21d	0.72c	2.96bc
SP50T50	11.02c	0.24cd	0.75c	2.54cd
LSD(0.05)	0.99	0.02	0.04	0.44
SE	0.35	0.01	0.01	0.16
RATES*POP	5.53ns	0.02*	0.01*	0.32ns

LSD: Least significant differences, SE: Standard error, SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between rate and population

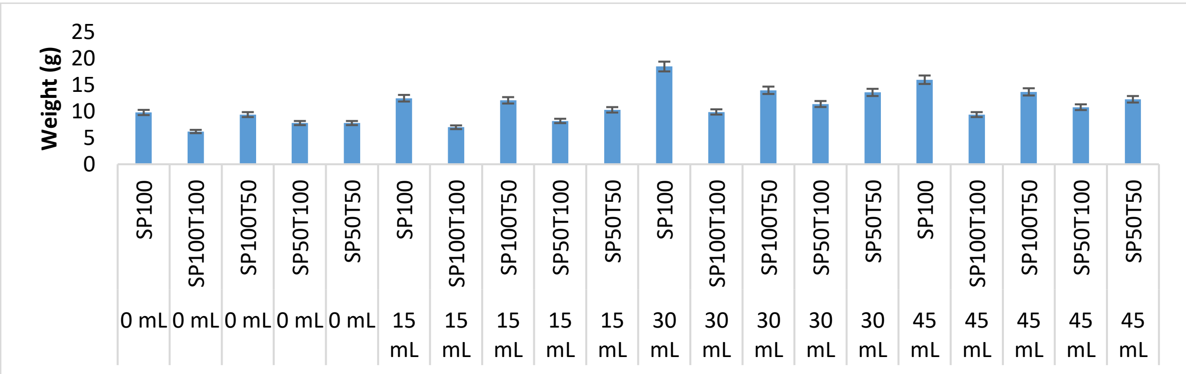

Fig 4: Interactive effect of fertilizer rates and intercrop system on the weight of dry fodder of sweet potato

Keys: SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between rate and population.

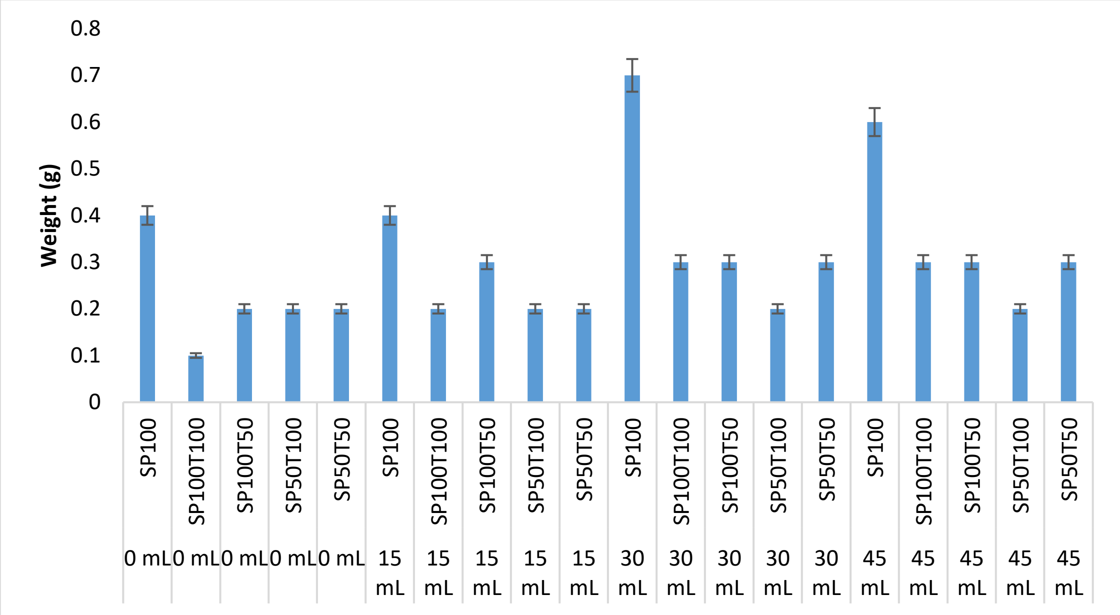

Fig 5: Interactive effect of fertilizer rates and intercrop system on the WODF of sweet potato

Keys: SP100: sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each. Rate*Pop: Interaction between rate and population

Table 8: Land Equivalent Ratio of the sweet potato and tomato intercrop

Cropping system	Sweetpotato yield	Relative yield	LER	Intercrop yield advantage (%)
SP100	14.22	0.258	-	
SP100T100	8.12	0.147	1.3039	30.4
SP100T50	12.28	0.223	1.59264	59.3
SP50T100	9.53	0.173	1.52939	52.9
SP50T50	11.02	0.18	1.59079	59.1

SP100: Sweet potato at 100% population, SP100T100: Sweet potato and tomato at 100% population density each, SP100T50: Sweet potato at 100% density and tomato at 50% density, SP50T100: Sweet potato at 50% density and tomato at 100% density, SP50T50: Sweet potato and tomato at 50% density each.

Discussion

Sweet potato plant is an arable crop that offers valuable nutrients to the consumers, however, the production rate is below the demand (Nedunchezhiyan *et al.*, 2012) [14]. This provides an opportunity to producers and an avenue to exploit several alternatives to increase the production to meet the consumers demands. One of such solution is the identification of adequate land with nutrient balance, and the utilization of scarce available space for the cultivation (Essilfie *et al.*, 2016) [4]. In this study, the soil pH of the cultivated area fell within the recommended range (5.8 to 6.2) for sweet potato cultivation, and this help in availing the available essential and macronutrients inherent and supplied for the growth and yield of the plants. The pH value range of 5.8 to 6.0 has earlier been reported as the best range for the cultivation of sweet potato by Brandenberger *et al.* (2014) [3] and Inheong *et al.* (2023) [6]. However, in times of low nutrient availability that necessitates the application of synthetic fertilizer, there is high possibility for the acidification of the land area (Mwanga *et al*., 2017) [12], while the use of organic fertilizer presents a better opportunity for stabilizing the soil environment without harm to non-target organisms (Uwamahoro *et al*., 2023) [18].

In this study, the higher rate of liquid fertilizer amendment (45 ml) enhanced the growth and development of the sweetpotato and tomato plants, and in this case, the improved performances also led to a higher yield. Shah *et al.* (2020) [17] had earlier suggested the need to improve the growth and productivity of sweet potato with a moderate amount of fertilizer amendment. Mukhtar *et al.* (2022) [11] had also reported the significant enhancement of sweet potato with fertilizer application. This showed that unlike the initial soil nutrient status could still carry the growth and yield of the sweet potato plants leading to a negligible difference in the yield of sweet potato plants in both non-amended and amended plots, the non and less dose amendment in the second experiment performed less than the higher rate liquid fertilizer amendment in terms of yield. This agrees with the findings of Viktor *et al*. (2023) [19]. However, this could also be due to the presence of two different plants feeding the available nutrients in the plots, thus leading to a higher nutrient depletion rate due to the competition for nutrient, available water, and space.

In terms of the sweet potato plant performances at different plant population and intercrop with tomato, the 100% sole planted sweet potato plants had better agronomic and yield (FTW, WODF and WOFFH) performances than other population, however, in terms of Fresh Tuber Number (FTN), the 100% sweet potato plants planted along with 50% tomato plant produce the highest number of fresh tubers. However, despite producing higher number of fresh tubers, the weight was still less than the 100% solely planted sweet potato plants, which mean that the tubers produced by the 100% sweetpotato planted along the 50% tomato were light. Mbayaki and Karuku (2021) [10] had earlier reported that the monocrop of sweet potato performs better than the intercrop. However, there have been reports of intercropping sweet potato with other crops like maize, cowpeas etc, (Mbayaki and Karuku, 2021) [10], but there is dearth of information on the intercrop of sweet potato and tomato. Also, the higher population density may have increased the competition in the plots and led to the yield reduction.

Also, considering the land equivalent ratio where both plants planted in same plot as intercrop, all the intercrop performed better than either of the plants planted solely with a minimum percentage advantage of 30.4% and maximum percentage advantage of 59.3% in this experiment. This tells that the sole crop of either sweet potato or tomato have to be grown in a range of 1.3 – 2.97 hectares of land to match the productivity of the intercrop. This agrees with the findings of Kichu *et al*. (2022) [9].

Conclusion

To avert the spill-over effect of synthetic fertilizer on the environment emanating from the cultivation of sweet potato, this study had shown that the application of liquid organic fertilizer at the rate of 45 mL per 4-meter square plot is optimal for improved sweet potato productivity. In a 100% capacity sweet potato farm, tomato should be intercropped at the rate of 50% capacity for enhanced productivity. This gives a land equivalent ratio of 159% over the sole cropping system.

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