Performance of *Senecio biafrae* (Oliv. & Hiern) J. Moore under Varying Light Intensities and Compost Rates in Ibadan, Southwestern Nigeria

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Abstract
Solanecio biafrae is an underutilized indigenous vegetable in southwest Nigeria. It is usually found in shades of other tree crops. This study investigated growth of S. biafrae as influenced by compost application under different light intensities in Ibadan, Southwest Nigeria. The pot study was conducted twice at the Crop Garden of the Department of Crop Protection and Environmental Biology, University of Ibadan. Four levels of light intensities were examined under multiple layers of nets: Growth under four test light intensities of unshaded natural light (0 net), and three levels of shades (1 net, 2 nets and 3 nets) assessed under four levels (0, 10, 15 and 20 g/pot) of compost (ratio 3:1 Tithonia-Poultry waste) in a randomized complete block design with light intensity as Blocks. Growth and yield data were analysed using analysis of variance and post-hoc tests conducted with Fisher's LSD at 5% probability. Lowest light intensity resulted in increased number of leaves, from 7.75 to 15.50 at 4 WAT and 7.78 to 18.50 at 6 WAT. Application of 20 g/pot compost resulted in higher number of leaves, number of nodes, vine height, vine diameter, root and shoot dry matter of S. biafrae under reduced light intensities. Low light intensity in combination with increased compost rates enhanced growth performance of S. biafrae. Cultivation of S. biafrae is recommended using of Tithonia diversifolia compost at the rate of 20g/5kg soil under low light intensity for optimum yield.

Keywords: compost, indigenous vegetables, light requirement, *Solanecio biafrae*, *Tithonia diversifolia*

Introduction

Indigenous vegetables that have been abandoned in favour of exotic ones are now regaining popularity across Africa. Abukutsa-Onyango (2007) reported that there is a diversity of African indigenous vegetables with nutritional and economic potentials that need to be exploited. Most of these vegetables are however not readily available because few stands are left in the wild resulting from neglect (Adebooye *et al.,* 2003). *Solanecio biafrae* (Oliv. and Hiern C. Jeffrey; (syn.) *Crassocephalum biafrae* (Oliv. and Hiern, S. Moore), family Asteraceae occurs naturally in the forest zone from Guinea to Uganda (Adebooye, 2000). It is an underutilized and threatened vegetable due to environmental and agronomic reasons (Famurewa, 2011; Awodoyin *et al.*, 2013). It is cultivated on a small scale, mainly in Nigeria, Uganda and Cameroon. There are other reports that *Solanecio biafrae* occurs in the wild (Adebooye, 2000; Bello *et al.,* 2018) and when cultivated, it is restricted to humid environment, well drained fertile soils under cocoa and oil palm plantations (Awodoyin, 2013) Thus, it is rare to encounter this vegetable in Nigerian markets when compared to other potherbs.

Solanecio biafrae is usually collected for consumption in the wild (Adebooye, 2004). It is locally called "*Worowo*" in southwest Nigeria, and in Sierra Leone it is known as "*Bologni"*. It is sometimes cultivated and staked on trellis of about 1 m tall in few homestead gardens (Fasuyi, 2006). Its consumption is of great health benefits because it inhibits lipid absorption due to the presence of saponin and tanin in its leaves (Ajiboye *et al.,* 2013); as well as its inhibition of cholesterol esterase, activation of fatty acid synthase, acetyl CoA carboxylase and production of triglyceride precursors such as acetyl CoA carboxylase and glycerol phosphate (Sharmila *et al.,* 2007; Udenze *et al.,* 2012). Its composition of high soluble dietary fibre in the leaves has been reported to reduce serum lipid profile (Ajiboye *et al.,* 2013).

Solanecio biafrae is an understory climber in the rainforest zone of west and central Africa, where average annual rainfall is about 1500 mm at an altitude of 1300 m above sea –level. It strongly responds to water stress by developing shriveled stems and yellow leaves and cannot survive under dry condition. Provision of shade is essential for good growth as it thrives well in a moist, well-drained soil rich in organic matter. This indicates that adequate light, water and soil conditions are essential for its optimum production. The leaf yield of *Solanecio biafrae* is about 7 kg/m^2 at the first harvest and 40 kg/m^2 per year. Higher yields are reported in *Solanecio biafrae*, as with many indigenous vegetables during the rainy season (Adebooye, 2018). As an understory potherb, its culinary, environmental, social and cultural services and functions were reported by Awodoyin *et al* (2013) to be under threats of weed invasion and use of chemical herbicides in cocoa plantation. They recommended an understanding of the agronomic requirements of *Solanecio biafrae* for field cultivation in order to ensure its sustainable cultivation.

There is a need to understand response of *Solanecio biafrae* to varying light intensity and compost application rates if its potentials must be productively harnessed for health benefits when consumed. The objectives of the study were to determine optimum light intensity necessary for cultivation of *Solanecio biafrae* in Southwest Nigeria; and to determine the level of compost necessary for optimum yield in Southwest Nigeria,

Materials and Methods

Description of the study area

The study was conducted at the Crop Garden of the Department of Crop Protection and Environmental Biology, Faculty of Agriculture and Forestry, University of Ibadan, Ibadan, Nigeria on latitude N07°27`04.9``and longitude E03°53`49.1`` with an elevation of 234 m above the sea level in Southwest Nigeria. The annual rainfall of the study area is between 1250 mm and 2250 mm with a mean photoperiod of 11.30 hours. Rainfall is bimodal with peaks in June and September (Egbinola and Amobichukwu, 2013).

Preparation of experimental materials

The experimental unit, i.e. plant materials was obtained from vine cuttings of *S. biafrae* obtained from Oje market, well-known for marketing indigenous vegetables in Ibadan, Oyo State, following Adeniji (2014). Each vine cutting contained four nodes. Compost prepared form Mexican sunflower (*Tithonia diversifolia*) and poultry manure mixed in a ratio 3:1 was used as soil amendments. The composting process was done in a plastic bucket fitted with an outlet pipe in order to aid passage of air for aerobic decomposition. The mixture was stirred and irrigated fortnightly and monitored for twelve weeks when the compost matured (FAO, 2010). At maturity, the compost was evacuated from the bucket, air dried, and later sieved to remove chaff, after which it was shredded and bagged till needed.

Treatments and design of Experiment

The experiment was laid out in a randomized complete block design (RCBD) with four replicates set up in open metal cage of 2 m × 1 m × 1.5 m dimension. Each cage was covered with layers of blue coloured net of 0.5 mm mesh which served as Blocks. Daylight intensity was adjusted by shading each cage with 3, 2, 1 and 0 layers of net to achieve an estimated intensity of 25%, 50%, 75% and 100% respectively. Each *S. biafrae* vine cutting (with four nodes) was planted in a nursery bag filled with 5 kg river sand. Four levels of compost at the rate of 0 g/5 kg (the control), 10 g/5 kg, 15 g/5 kg, and 20 g/5 kg soil equivalent to 0 kg/ha, 4488 kg/ha, 6732 kg/ha and 8976 kg/ha were used.

The nursery bags were arranged in four replicates in each netted cage. Actual light intensities in the cages were determined using a light (lux) meter. Light intensities in the cages were measured at 10.00; 12.00 and 14.00 hours at the fourth and sixth weeks after transplanting. The light intensities were determined on three consecutive days (Monday – Wednesday) in order to account for variability in light intensity using HoldPeak Dispart and Coalescent Lux meter Model HP-881A. Weeding and watering to field capacity were performed at two days intervals, and insect pests were controlled with Cypermethrin EC at the rate of 1.5 ml/l when infestation by white flies was first noticed.

Data collection and Analyses

At four and at six weeks after transplanting, vine length, leaf area using graph paper method of Tayo and Togun (1984), number of leaves, stem diameter, and number of nodes were measured or counted as appropriate. Yield parameters assessed were fresh and dry shoot and root weights. The shoots and roots were oven dried weights at 80 until constant weight, then weighed with Metler Balance P1210. All the data were analysed using analysis of variance from which means that were significant were separated using Fisher's LSD at 5% level of probability.

Results

Physico-chemical properties of the compost and soil used for the experiment

The soil used for the experiment was sandy loam in texture and slightly acidic (pH = 6.83) with a high Carbon: Nitrogen ratio of 19:1. The soil contained low nitrogen, but high in phosphorus and potassium (Table 1). The *Tithomia diversifolia* and poultry manure based compost used for the experiment had higher nitrogen and potassium compared to the soil (Table 1).

Table 1: Physico-chemical parameters of pre-cropping soil and compost used for the experiment

Properties	Soil	Compost
Particle size (%)		
Clay	15.13	Na
Silt	2.93	Na
Sand	81.98	Na
Textural class	Sandy Loam*	
pH (H_2O)	6.83	ND
Organic carbon (g/kg)	19.16	ND
N (g/kg)	1.57	2.73
P (mg/kg)	17.78	1.17
Exchangeable acidity	0.10	ND
K (cmol/kg)	0.28	1.08
Ca (cmol/kg)	1.82	1.74
Mg (cmol/kg)	0.79	1.06
Na (cmol/kg)	0.32	0.10
Mn (mg/kg)	75.17	0.06
Fe (mg/kg)	59.00	1.48
Cu (mg/kg)	3.11	0.01
Zn (mg/kg)	2.13	0.01
Organic matter (g/kg)	56.24	38.00

Na= Not applicable, ND = Not Determined
*USDA Classification

Effect of light intensity and compost application on leaf area of *S. biafrae*

The light intensity peaked at midday at 4 WAT, whereas at the 6 WAT, the peak was recorded in the morning (9.00 am) as shown in Figures 1 and 2. The leaf area of the vegetable was generally highest under compost application rate of 20g/5kg soil under the three levels of light intensity based on increasing layers of net (3.97 cm^2 in zero net to 34.32 cm^2 in three nets) compared to other application rates (Table 2). Reducing light intensity through the use of nets from unobstructed solar radiation reception tend to increase the leaf area of the vegetable as indicated in Table 2. Comparing the influence of compost application to performance under light of different intensities, at 4 WAT, the leaf area of the vegetable under compost application of 20 g/5 kg soil was significantly greater under one and two layers of net than in unobstructed light. However, there were no significant differences in the leaf area of the plant under no compost treatments and other levels of compost application under one and two nets The leaf area of the vegetable in all compost treatments covered with three layers of net did not exhibit any significant difference despite progressive increase in leaf area with increase in compost application rates. Similar trends were observed at 6 WAT at $P \leq 0.05$ (Table 2).

The number of leaves of *S. biafrae* under varying light intensities ranged from 4.75 to 5.25 number of leaves under no net to a range of 3.5 to 7.00 leaves under one layer of net (with a lux range of 500 Lux to 720 Lux). Significant increases in number of leaves were not observed with compost application rates of 0 and 10 g/5 kg soil (7.75 and 9.75) and between 15 and 20 g/5 kg soil (13.75 and 15.50) under two and three layers of net respectively. The increase in mean number of leaves (3.5 to 13.75 and

Table 2: Effect of different light intensity and compost rates on leaf area (cm^2) of *S. biafrae*

Compost (g/5 kg soil)	Net Layers							
	4 WAT				6 WAT			
	0	1	2	3	0	1	2	3
0	3.97	5.96	9.52	33.76	5.25	6.21	9.40	33.96
10	5.21	7.80	16.18	33.74	6.25	7.43	16.18	34.19
15	5.52	8.25	17.15	32.23	5.77	8.25	17.17	32.63
20	8.72	12.70	20.83	34.32	9.12	12.95	20.95	39.80
LSD ($p \leq 0.05$)	1.65	2.43	4.35	NS	2.67	2.55	4.32	NS

WAT = Weeks after Transplanting

15.50) was significant when the performance of the vegetable was in the no compost was compared with 15 and 20 g/5kg soil compost rates Experimental units under 20 g/5 kg soil compost application rate performed better than plants under any of the other rate (Table 3).

The lengths of vines of the vegetable were not significantly different across all compost application rates under no net and one layer of net, except under three layers of net where the highest value (15.50 cm) was obtained with compost application rate of 20 g/5 kg soil at 4 WAT. No significant difference was observed among all compost treatments at 6 WAT under one, two and three layers of net. At 6 WAT, the highest length of vine (31.95 cm) was recorded at the compost application rate of 20 g/5 kg soil (Table 4).

The response of vine diameter (1.50 mm) to variations in light intensity and compost application was different between no net under 0 g/5 kg soil compost level and 20 g/5 kg soil (2.14 mm). The trend was the same for one and two layers of nets, but the difference in vine diameter showed in both the 20 g/5 kg soil compost level (4.04 mm) at six WAT.

Table 3: Effect of light intensity and compost on number of leaves of *S. biafrae* in Ibadan in 2014

Compost	Net Layers							
	4 WAT				6 WAT			
(g/5 kg soil)	0	1	2	3	0	1	3	4
0	4.75	5.00	5.25	7.75	5.50	4.00	5.25	7.78
10	3.50	3.50	3.75	9.75	4.50	5.50	3.75	9.85
15	3.25	4.50	6.75	13.75	4.50	5.50	6.75	13.95
20	5.25	7.00	7.50	15.50	5.50	7.75	7.90	18.50
$LSD_{0.05}$	1.65	2.43	NS	6.91	NS	3.25	4.43	7.36

Footnote: WAT means Weeks after Transplanting

Only compost application rate of 20g/5kg soil induced highest increase in vine diameter at all levels of light intensity (Table 5). The vine length and vine diameter of the vegetable increased with increasing shade and with increasing level of compost applied in the second trial (Tables 4 and 5).

Table 4: Effect of light intensity and compost on vine length (cm) of *S. biafrae* in Ibadan in 2014

	Net Layers							
	4 WAT				6 WAT			
Compost (g/5 kg soil)	0	1	2	3	0	1	2	3
0	8.87	11.25	11.75	17.82	8.75	12.25	11.75	18.45
10	6.12	8.25	9.87	23.35	6.37	13.25	10.00	24.35
15	6.25	13.75	13.97	28.87	6.25	8.75	13.12	29.37
20	9.4	14.75	18.00	30.95	10.37	14.98	19.00	31.95
$LSD_{0.05}$	NS	NS	7.36	NS	NS	NS	NS	NS

WAT = Weeks after Transplanting

Table 5: Effect of light intensity and compost on vine diameter (mm) of *S. biafrae* in Ibadan in 2014

Duration	Net Layers							
Compost	4 WAT				6 WAT			
(g/5 kg soil)	0	1	2	3	0	1	2	3
0	1.50	1.92	1.79	1.85	2.70	2.83	2.89	3.23
10	1.32	1.09	1.86	1.92	2.35	2.89	2.93	3.24
15	1.56	1.87	1.89	1.96	2.70	2.87	2.90	3.23
20	1.69	2.52	2.58	2.59	2.72	3.85	3.90	4.04
$LSD_{0.05}$	NS	NS	NS	NS	NS	NS	NS	0.79

Footnote: WAT means Weeks after Transplanting

Table 6: Dry weights (g) of root and shoot of *Solanecio biafrae* grown under varying light intensities and compost rates

Net Layers	0		1		2		3	
Compost Level (g/5 kg soil)	Root	Shoot	Root	Shoot	Root	Shoot	Root	Shoot
0	0.10	1.15	050	0.90	0.35	0.85	0.55	1.60
10	0.10	1.00	0.60	0.95	0.40	0.95	0.70	2.25
15	0.20	1.15	0.65	0.10	0.70	1.30	0.80	2.55
20	0.25	1.15	0.80	0.16	0.75	1.40	0.85	3.05
$LSD_{(0.05)}$	0.21	NS	NS	0.24	0.25	1.06	1.06	2.17

WAT = Weeks after Transplanting

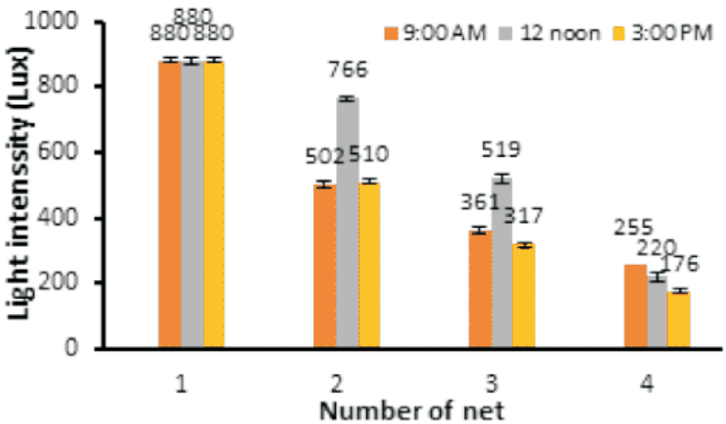

Figure 1: Variation in light intensity under different layers of net at 4 weeks after transplanting
n = 3, Error bars = Standard Error

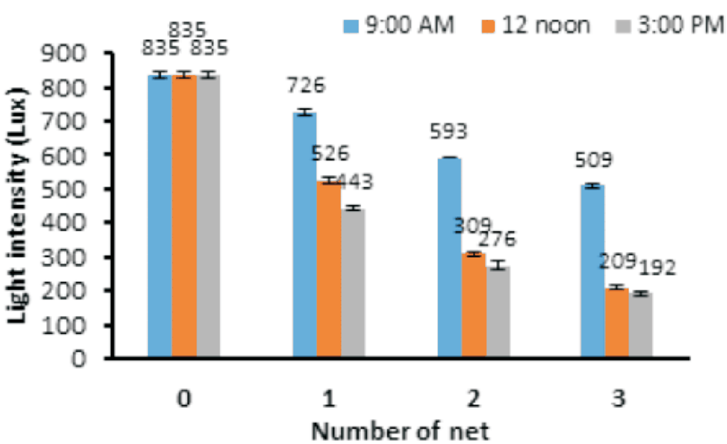

Figure 2: Variation in light intensity under different layers of net at six weeks after transplanting
n = 3, Error bars = Standard Error

The root and shoot weights of *S. biafrae* responded progressively as the shade and compost concentration increased. The shoot however accumulated more biomass than the root (Table 6). The lowest dry root weight (0.1 g) and shoot dry weight (1.15 g) recorded was in no shade (no net) with no compost application; while the highest dry root dry weight (0.85 g) and shoot dry weight (3.05 g) were recorded in plants grown under 3 net layers and supplied with compost at the rate of 20 g/pot (Table 6). Significantly higher biomass was recorded in roots and shoots of the vegetable cultivated under the highest level of compost application compared to other rates under the different light intensities.

Discussion and conclusion

Optimum crop performance is usually limited by light and inadequate availability of essential nutrients in the soil, necessitating addition of soil amendments, especially from organic sources because of their reported longer residual effects when applied to the soil (Adeniyan and Ojeniyi, 2003). The study confirmed that reduced light intensity aids propagation and growth of *Solanecio biafrae*. *Solanecio biafrae* performed better under low light intensity (20% – 29% of full day light) and under 20 g/pot of compost rate. The beneficial performance following a decreasing light intensity and increasing compost rate thus put *S. biafrae* as one of potherbs that grows best under reduced light intensity and nutrient supplementation. The findings of this study complement the work of Giwa and Ojeniyi (2004) that high rate of manure is effective in ensuring better performance in growth parameters of *S. biafrae.*

This study provided empirical support to the distribution of *S. biafrae* under shade of cocoa tree as observed by Awodoyin *et al.* (2013). It also clearly demonstrated that the vegetable could benefit from high rate of compost application. The 20 g/5 kg soil compost rate might have augment the supply of nutrient by the soil to the vegetable. There was a strong indication that the addition of compost at the rate supplied helped improve the performance of the shoot and root dry weights of the crop, as experimental units under control treatments performed less than all treatments with compost application. This followed the observation of Dada and Fayinminu (2010) in okra that efficient uptake and utilization of applied nutrient for crop growth, development and yield is dependent on appropriate timing of weed removal and rate of applied nutrient. A similar result was obtained by Akanbi *et al.* (2000) where treatments without compost application had poor vegetative development.

Solanecio biafrae vegetable benefitted from compost application under a reduced light intensity. So far, the optimal compost requirement to improve *Solanecio biafrae* performance is 20 g/pot under a mean low light intensity of 193.58±1.221 lux. This could easily and cheaply be achieved under either under a perennial crop plantation with cocoa, orange or mango as main crops; or under an agroforestry system. Its domestication could be promoted in backyard gardens where shade and organic amendments could be supplied, and where it would make a good candidate crop for food security and alleviation of poverty in urban and peri-urban agricultural setting.

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