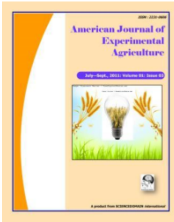

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Integrated Harvesting Techniques for African Egg Plant (*Solanum macrocarpon* L., cv. Igbagba)

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Research Article

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ABSTRACT

This study elucidated the influence of harvesting height and frequency on concurrent seed and shoots production of the African Eggplant, *Solanum macrocarpon* L., cv. Igbagba/Igbo. The overall aim was to use the outcome to make recommendations that would enable African resource poor farmers secure the much needed increase in income for improved livelihoods. The study was carried out between April to November 2004 on the National Horticultural Research Institute (NIHORT) Ibadan, Nigeria commercial vegetable production fields. Result shows that harvesting at 0.08 m above ground level was optimal and significantly highest for leaf, stem, shoot, seed and total yields except at 0.12 m above ground level for seed production. The result of financial profitability analysis shows that harvesting 0.08 m above ground level and fortnightly was most profitable for leaf, shoot and total yields compared to all the treatment combinations. Harvesting 0.12 m above ground level and monthly, however, was most profitable for seed production when compared to all treatments combinations. The study concluded noting that integrated harvesting techniques for shoot (leaf + stem) and seed production proved economically viable and optimize resource use efficiency better than growing *S. macrocarpon* sole either for shoot or seed.

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Keywords: African egg plant; harvesting techniques; financial profitability; smallholder farmers; Nigeria;

1. INTRODUCTION

Sub-Sahara Africa (SSA) is the only region of the world where per capita food production has steadily declined over the past two decades (IBRD, 1989). Nowhere in the word are the linkages between agricultural and poverty strongest than in Africa, specifically SSA. In recent years rapid demographic and economic changes have worsened the situation (Ojo, 1994). Global agricultural abuses and mismanagement are the primary cause of poverty. Unfavorable farming policies and declining investment in research are partly responsible for the low food production output (Ehui et al., 1993). Thus the challenge faced by decision makers in many nations of SSA is how to feed an increasing population without irreparable damage to the natural resource base upon which agricultural production depends.

Despite the nutritional quantity and qualities of *Solanum macrocarpon* (Oboh et al., 2005; Ojo and Olufolaji, 1997), it is of great importance for medicinal purposes (Anosike et al., 2011; Guiama et al., 2010); and has potential for the vegetable industry. It has found off-season production prominence among in-land valley growers, urban and peri-urban gardeners, and peasant farmers especially in dry season, thus is important in diversifying and improving the food basket, thereby contributing to food security of the region.

There is little known about the cultural practices needed to optimize the production of African Eggplant, *Solanum macrocarpon* L., cv. Igbagba/Igbo in sub-Saharan Africa. *S. macrocarpon* is mainly grown for the shoot (leaf + stem). However, it could be concurrently managed for shoot and seed. The cutting of apical meristem prior to onset of flowering is a common agronomic practice that could increase yield, provide seed growers additional income from the sale of leafy vegetables; and can delay or extend seed harvest against period of surplus for maximum profit (Ron et al., 1995; Ojo et al., 2001; Blank et al., 2005). Understanding this clipping phenomenon is vital for improving African crop productivity, optimizing agricultural resource use efficiency and policy formulation for economic viability and sustainability (BIFAD 1988; CGIAR 1989). This study, therefore, aimed at elucidating the influence of harvesting height and frequency on concurrent seed and shoot production of *S. macrocarpon* in an attempt to increase the income of African resource poor farmers.

2. MATERIALS AND METHODS

2.1 Experimental Site and Data Collection

The trial was carried out at the experimental site of the National Horticultural Research Institute of Nigeria, NIHORT, Ibadan, Nigeria. The site had: - organic carbon, 19.9g/kg; Nitrogen, 0.12%; Bray-1-P, 6.5mg/kg; potassium, 0.18Cmol/kg; ECEC, 6.28Cmol/kg; and sandy clay loam texture. There are two cropping seasons (long and short cropping seasons) in this area. While the long cropping season stretches from April to July, the short cropping season stretches from August to October/November of each year. The data used for this article were collected during the long and the short cropping seasons of 2004.

2.2 Growing the Seedlings

S. macrocarpon was drilled at 0.50m rows and thinned two weeks after planting (WAP) to appropriate densities of 0.50 x 0.50 m which corresponded to 40, 000 plants/ha.

2.3 Experimental Design

The experiment was a three (harvesting heights of 0.04 m, 0.08 m and 0.12 m) by five (harvesting frequencies of 1x per 1,2,3,4 and 5 weeks) factorial treatment arrangements fitted into randomized complete block with 4 replications. There was a control treatment which was harvested at ground level six weeks after planting for vegetative yield estimation and a check which was left for seeding without cutting. Net plot size was 5 m x 5 m (25 m^2).

2.4 Agronomic Practices

At 3 WAP, Cypermethrine insecticide at 50 g a.i. per hectare was sprayed and 15:15:15 NPK applied at 60 kg/ha. Cutting treatments were imposed using hand-held shears starting 5 till 10 WAP on all plants per plot except for the check which was left for seed production without cutting and the control that was cut at ground level 5 WAP for shoot (leaf + stem) production. After cutting treatments plants were left to seed. Plots were hand-hoed and manually weeded.

2.5 Data Collection and Analysis

Cumulative shoot fresh weight over the cutting period gave the shoot yield per plant. *S. macrocarpon* fruits were harvested, processed for seed and the seed weighed at 12% moisture content. Seed and shoot yield values were based on current NIHORT [National Horticultural Research Institute, Nigeria] prices of ₦450.00 per kilogram seed and ₦10.00 per kilogram shoot (US$1 = ₦80 at time of data collection, ₦ is Nigerian Currency). Harvest index was calculated as seed weight/shoot weight which indicates changes in the pattern of dry matter partitioning into seed and shoot. Cutting Use Efficiency (CUE) was defined as the relative agronomic efficiency of using cutting over the control. Data were subjected to analyses of variance by the procedure of the Statistical Analysis System (SAS, 2005) using mean of 10 plants per treatment plot. Marginal revenue (MR) equals field price per kilogram multiplied by average yield (kg/ha) where field price is the market value of one kilogram of the crop. Marginal cost (MC) included those costs that are affected by the alternative treatment being considered (costs such as planting, land purchase, land preparation and transport that do not differ across treatments will be incurred regardless of which treatments is used). Data from both seasons (long cropping season and short cropping season) for each treatment were combined because there were no seasonal significant differences. Means were compared using Duncan's Multiple Range Test (DMRT) at 5% significance.

3. RESULTS

3.1 Harvesting Height and Frequency on *S. macrocarpon* Yield

Figure 1 shows that harvesting at 0.08 m above ground level (AGL) was optimal and significantly highest for leaf, stem, shoot, seed and total yields except at 0.12 m AGL for seed production. Harvesting fortnightly (1x per 2 weeks) revealed optimal and significant leaf, stem, shoot and total yields over the control (Table 1). Harvesting once in a month (1x per 4 weeks), however, was highest and significantly favors seed production over the check (Table 1).

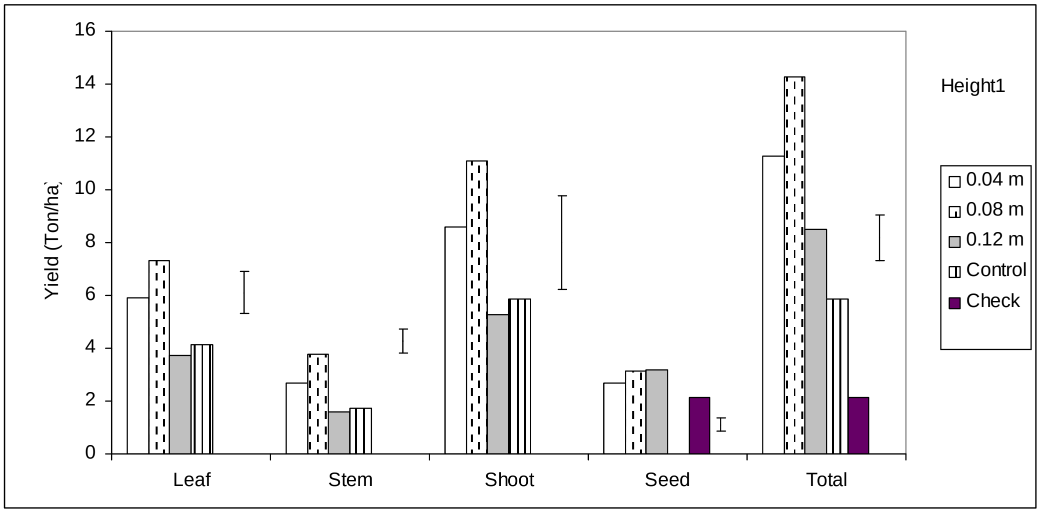

Figure 1: Influence of Harvesting height on *Solanum macrocarpon* yield (averaged across harvesting frequencies)

[1]Height = above ground level (m); control= cutting 6 weeks after planning at ground level for shoot (leaf+ stem) production only; check= left uncut till final harvesting for seed production only. Error bars represent SED (Standard Error of Deviation)

Source: Experimental data, 2004

Table 1: Influence of harvesting frequency on *Solanum macrocarpon* yield (averaged across cutting heights)

Frequency[1]	Yield (ton/ha)				Total
	Leaf	Stem	Shoot	Seed	
1x per week	6.03	2.20	8.23	3.87	12.09
1x per 2 weeks	7.14	3.96	11.10	3.64	14.73
1x per 3 weeks	5.60	3.26	8.87	2.78	11.64
1x per 4 weeks	2.70	1.38	4.08	4.90	8.98
1x per 5 weeks	2.85	1.43	4.28	4.62	8.90
Control	4.13	1.73	5.87	-	5.87
Check	-	-	-	2.14	2.14
LSD(5%)	0.75	0.61	1.50	0.65	1.83

[1]Control = cutting 6 weeks after planting at ground level for shoot (leaf+ stem) production only; check= left uncut till final harvest for seed production only.

Source: Experimental data, 2004

3.2 Harvesting Height and Frequency on *S. macrocarpon* Agronomic Parameters

Seed production CUE was highest at 1x harvesting per month (4 weeks). HI was highest cutting 0.04 m AGL once in 5 weeks compared to other treatments combinations (Table 2).

Table 2: Harvesting height x frequency interaction on agronomic parameters in *S. macrocarpon*

Height[1]	Frequency	Harvest Index	% Cutting Use Efficiency (CUE)[2]				Total
			Leaf	Stem	Shoot	Seed	
0.04 m	Control	-	-	-	-	-	44.59
	Check	-	-	-	-	-	-
	1 week	27.97	59.29	33.45	48.48	58.00	73.21
	2 weeks	24.32	77.86	72.93	75.93	53.79	85.52
	3 weeks	23.99	52.26	57.36	54.59	38.16	70.73
	4 weeks	39.24	51.67	30.80	42.96	76.68	58.70
	5 weeks	49.89	49.17	29.68	41.05	71.59	58.33
0.08 m	Control	-	-	-	-	-	59.08
	Check	-	-	-	-	-	-
	1 week	27.05	81.44	60.52	72.55	79.35	87.69
	2 weeks	23.39	100.00	100.00	100.00	75.13	100.00
	3 weeks	23.06	74.40	84.43	78.66	59.51	85.22
	4 weeks	38.32	73.81	57.87	67.04	98.02	73.19
	5 weeks	36.99	71.31	57.75	65.13	92.94	72.82
0.12 m	Control	-	-	-	-	-	30.94
	Check	-	-	-	-	-	-
	1 week	34.81	38.15	14.08	28.03	81.33	59.56
	2 weeks	31.16	56.72	53.56	55.48	77.11	71.86
	3 weeks	30.82	31.12	37.99	34.14	61.49	57.08
	4 weeks	46.08	30.52	11.43	22.51	100.00	45.05
	5 weeks	44.75	28.02	30.31	20.60	94.92	44.68

[1]Control = cutting six weeks after planting at ground level for shoot (Leaf + Stem) production only; Check = Left uncut till final harvest for seed production only. [2]CUE = (Yield of cutting height – yield of control x 100)/Maximum yield of cutting height – Yield of control
Source: Experimental data, 2004

3.3 Harvesting Height and Frequency on *S. macrocarpon* Crop Values

The financial profitability of this business as indicated by the ratio of Marginal Revenue to Marginal Cost (MR:MC) showed that harvesting 0.08 m AGL fortnightly was most profitable for leaf, shoot and total yields compared to all the treatment combinations (Table 3). Harvesting 0.12 m AGL monthly, however, was most profitable for seed production when compared to all treatments combinations (Table 3).

4. DISCUSSION

In previous works, celosia shoot yield were reported and recommended at 0.01 m cutting height (Grubben, 1976; Ojo, 2001). In this study however, fortnight 0.08 m cutting height AGL should provide high and stable *S. macrocarpon* shoot and seed yields. Harvest Index which indicates changes in the pattern of dry matter partitioning into seed and shoot could be used as an indicator of changes observed in shoot (leaf + stem) yield, while Cutting Use Efficiency (CUE) may indicate changes in seed yield. Increasing harvest frequencies decreased HI, partly through reduced leaf size. The pattern of decline of Harvest Index (assimilate source) with increasing harvesting frequencies was highly correlated with seed yield (economic sink), stressing the basic fact of the green shoot (vegetative plant portion) as determinant of yield.

Table 3: Economics of harvesting height x frequency interaction on *S. macrocarpon* yield

Height[1]	Frequency[2]	Marginal Revenue (MR)[3]			Total	MR:MC[4]			Total
		Leaf	Shoot	Seed		Leaf	Shoot	Seed	
0.04 m	Control	48528	70580	-	83140	29.23	42.51	-	32.43
	Check	-	-	29780	72128	-	-	12.10	22.37
	1 week	57748	82136	30400	112806	30.86	44.06	12.36	27.91
	2 weeks	63416	96576	29240	126086	34.82	13.76	11.89	31.35
	3 weeks	55712	85412	24940	55984	30.93	47.23	10.14	27.87
	4 weeks	41284	61588	14615	97398	24.20	36.06	14.45	19.98
	5 weeks	42036	62588	34140	96998	24.62	36.61	13.88	25.16
0.08 m	Control	55568	83188	-	97988	33.47	50.11	-	26.57
	Check	-	-	32020	86976	-	-	13.01	26.51
	1 week	64788	94744	32640	127656	35.10	51.66	13.27	32.06
	2 weeks	70456	109184	31480	140934	39.06	60.46	12.79	35.49
	3 weeks	62752	98020	27180	125470	35.17	54.83	11.04	32.04
	4 weeks	48324	74196	37780	12246	28.44	43.66	15.36	29.39
	5 weeks	49076	75195	36380	111846	28.86	44.21	14.79	29.30
0.12 m	Control	37532	54136	-	69144	22.61	32.61	-	28.52
	Check	-	-	32228	58132	-	-	13.09	18.46
	1 week	46752	65692	32848	139452	35.10	34.16	13.35	23.99
	2 weeks	52420	80132	31688	112090	39.00	30.88	12.88	27.44
	3 weeks	44716	68968	27388	96626	35.17	22.33	11.13	23.96
	4 weeks	30288	45144	37988	83402	28.44	26.16	15.44	21.34
	5 weeks	31040	46144	36588	83002	28.86	26.71	14.87	28.52

[1]Cutting height in meter above the ground level; [2]Harvesting once per week (s) indicated. [3]Market price of vegetable = N10/kg; [4]MC = marginal cost (cost of shears = N1,500.00 k; Labour charges for leaf/shoot harvesting = N160/ha; and for fruit processing = N320/ha; at N80/Labour/day 0f 8 hrs Monday.

Source: Experimental data, 2004

Nevertheless, HI response to harvest frequency was not automatically reflected in seed and shoot yield increase in all the harvesting heights included in the study. This suggests that other parameters of canopy function such as leaf orientations, carbon fixation, branch number, assimilate use and partitioning could interact significantly in yield formation. A positive relationship was observed between yield and HI with increasing cutting height and frequency. These results suggest that cutting height and frequency enhance dry matter partitioning into seed and shoot in *S. macrocarpon* (Table 2). In *S. macrocarpon*, as in other similar leaf vegetables, leaf growth (assimilate source) has priority over seed development (assimilate sink). The leaf biomass is more sensitive to cutting height stimulus compared to that of seed. The present data confirms this trend, as the shoot cutting use efficiency (CUE) responded to cutting height stimulus than seed CUE (Table 2). Increased seed and shoot yields with increased cutting height could be explained by the high regenerative ability of *S. macrocarpon* when cut (Figure 1 and Table 1). The lateral shoots thus produced improved seed and shoot yields up to a level beyond which competition for plant nutrients and sunlight became limiting. Similar views were shared by Porat et al. (1995) and Trujilo et al. (1996). Cutting height enhanced branching in Celosia and this in turn increased seed and shoot yield production (Ojo, 2001). This findings by Ojo (2001) suggests that aerial apices (branching) are active source of assimilates in *S. macrocarpon*. Hence, increased aerial apices due to cutting potentially enhanced yield. Clipping 0.08 m AGL fortnightly had the highest seed + shoot (total) output of N140,934.00/ha (US$ 1,761.67/ha) over all other treatment combinations (Table 3). These suggest that cutting enhance economic gain and that seed production pays better than shoot production in terms of economic output.

5. CONCLUSION

Integrated harvesting techniques for shoot (leaf + stem) and seed production proved economically viable and optimize resource use efficiency better than growing *S. macrocarpon* sole for either shoot or seed as conventionally done.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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