

## POTENTIALS OF *IN SITU* SOLARIZATION WITH POLYETHYLENE ON WEED SUPPRESSION AND CASSAVA (*Manihot esculenta* Crantz) GROWTH AND YIELD

\*<sup>1</sup>Francis A. Nwagwu, <sup>1</sup>Okechukwu C. Umunnakwe and <sup>2</sup>Udensi E. Udensi

<sup>1</sup>Department of Crop Science, University of Calabar, Calabar, Nigeria

<sup>2</sup>Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, Nigeria

\*Corresponding Author Email: salemgo2016@gmail.com

### Abstract

Cassava is a major food security and cash crop in Nigeria, but yields remain low largely due to weed infestation. A field experiment was conducted during the 2019 and 2020 early cropping seasons at the University of Calabar Teaching and Research Farm, Calabar, to determine the potential of *in situ* solarization on weed suppression and cassava performance. Factorial combinations of two polyethylene film colours (black-B, transparent-W), and five *in situ* solarization durations {0 (no solarization/control), 8, 12, 16, and 48 weeks (coded S<sub>0</sub>, S<sub>1</sub>, S<sub>2</sub>, S<sub>3</sub>, S<sub>4</sub>, respectively), were laid out in randomized complete block design (RCBD) with three replications. Data collected on weeds, growth and yield of cassava were analyzed using the GenStat Package Version 8.1. Means were compared using the Least Significant Difference (LSD) at 5 % probability level. Results showed that polyethylene colour was not significant ( $p > 0.05$ ) on weed and crop growth, except plant height at 12 weeks after planting (WAP). *In situ* solarization duration and the interaction were significant. On the two-year average, *in situ* solarizations reduced weed density by 92.86 % and weed dry matter by 95.02 %; and enhanced cassava fresh root tuber yield per hectare by 97.61 %, relative to no solarization. Interactively, maximum cassava root tuber yields (64.00 and 64.35 t ha<sup>-1</sup>) were obtained from plots solarized for 48 weeks with white and black polyethylene sheets, respectively. These findings demonstrate that *in situ* solarization with black or white polyethylene sheet is highly effective in weed suppression and enhanced cassava yield.

**Key words:** *In situ* solarization, weed suppression, cassava, polyethylene, yield.

### Introduction

Cassava (*Manihot esculenta* Crantz) is one of the most important root crops of the world, especially in sub-Saharan Africa, where it is widely grown as a major staple food and cash crop (IITA, 2017). Nigeria is the world highest producer of cassava, due mostly to large hectares of land devoted to its production (FAO, 2025). However, the average cassava tuberous yield in Nigeria remains low. For instance, in 2023, Nigeria's average cassava tuberous yield was 6.35 t/ha, which was about 24 % of Indonesia's average yield of 26.57 t/ha (FAO, 2025). This poor yield of cassava in Nigeria has

been attributed to a number of factors, prominent among which is weed infestation (Onasanya *et al.*, 2021).

Weeds remain a major biotic constraint to cassava production around the world, leading to significant yield reductions in quality and quantity (Umunnakwe *et al.*, 2023a). In Nigeria, up to 95 % cassava yield losses as a result of unchecked weeds have been reported (Albuquerque *et al.*, 2012). Manual weeding is the most common method of weed control in West Africa (Melifonwu *et al.*, 2000). However, the drudgery, high cost and the need for repeated operations associated with hand-weeding have made the practice undesirable,

especially in large scale crop farms (Udensi *et al.*, 2012; Omovbude *et al.* 2017a, b; Nzeako *et al.*, 2019; Onasanya *et al.*, 2021). On the other hand, environmental concerns and health hazards associated with chemical weed control render it unattractive and unacceptable to many farmers and consumers of crop produce. It has therefore become necessary to explore alternative weed management strategies in cassava production (Umunnakwe *et al.*, 2023a, b), that will be effective, environmentally friendly, and economically viable. Soil solarization could be a good, environmentally friendly and cost-effective weed management alternative to chemical weed management strategy.

Soil solarization, also known as plastic mulching entails the covering of the soil surface with polyethylene film to promote the solar heating of the soil to temperatures inimical to weed propagules and soil borne pathogens (Nwagwu *et al.*, 2023a, b). The efficiency of this technology is best achieved when carried out on wet soil as water speeds up the conduction and transmission of the absorbed heat down the soil profile creating a greenhouse effect and the soil temperature rises to levels that are injurious or lethal to weed seeds and seedlings (Umunnakwe *et al.*, 2023b). The benefits of soil solarization have been listed to include: reduction in weed incidence, reduction in soil compaction, reduction in soil erosion, reduction in root pruning, reduction in nutrient leaching, reduction in the incidence of soil borne disease, distortion of the build-up of harmful insects, moisture conservation, cleaner and higher quality produce (Udensi *et al.*, 2025). There is paucity of information on the use of this technology in cassava production in Calabar and the neighboring farming communities, prompting further

inquiries into the suitability of the technology in farming systems of the southern humid agro-ecosystem.

## Materials and Methods

### Study location

The experiment was conducted at the Teaching and Research Farm of Crop Science Department, University of Calabar, Calabar, during the 2019 and 2020 cropping seasons. Calabar lies 39 m above sea level in the rainforest zone of Nigerian agro-ecology at latitude 4° 57' 0" N and longitude 8° 19' 30" E. The area is characterized by a relative humidity of 75 % to 88 %, mean annual temperature range of 27 ° C to 35 ° C and a rainfall distribution of 3,000 mm to 3,500 mm range (Efiong, 2011). The land was in secondary vegetation following a two-year fallow period after a previous cassava crop. The existing vegetation was cleared manually and the debris raked. The soil was tilled to a depth of 20 – 30 cm using spade and seedbeds raised 15 - 20 cm above-ground.

### Experimental design, treatments and layout

The experiment was a 2 x 5 factorial consisting of two polyethylene sheet colours (black and white) and five *in situ* solarization durations {0(non-solarized control), 56 days (8 weeks), 84 days (12 weeks), 112 days (16 weeks) and 336 days (48 weeks)}. The ten treatment combinations were laid out in randomized complete block design (RCBD) and replicated three times. Each experimental unit measured 4 m x 5 m with 1 m path separation between plots and blocks. The gross plot size was 29.00 m x 29.50 m (0.09 ha).

**Application of treatments, planting of cassava cuttings and fertilizer application:**

Black and transparent white polyethylene sheets with equal thickness of 100 microns (100  $\mu$ ), measuring 5.5 m x 4.5 m were spread over the surface of already prepared seedbeds measuring 5 m x 4 m, on the 9th of March each year. The edges of the polyethylene sheets were buried 10 – 15 cm into the soil to prevent them from being blown away by the wind. Circular slits of 10 cm radius were made at 1 m x 1 m spaces through which cassava (var. TME 419) cuttings of 20 – 25 cm length, with 4 - 7 nodes each were inserted in a slanting position. The cuttings were planted next day after laying the polyethylene sheets, one cutting per stand giving a population of 10,000 plants per hectare. The polyethylene sheets were later removed sequentially at 8, 12, 16 and 48 WAP, respectively, with the uncovered plots as the control. Mixed fertilizer NPK 12:12:17 was ring applied 10 cm from the base of the cassava plants at the rate of 400 kg ha<sup>-1</sup> in two split doses of 200 kg ha<sup>-1</sup> at 5 and 12 WAP.

**Data collection and statistical analysis:**

Plant growth parameters were measured eight-weekly at 4, 12, and 20 WAP, while weed data were collected at 4, 8 and 12 WAP. Weed density was determined using a 50cm x 50cm quadrat thrown along a diagonal transect within each plot and the total number of weeds present within the quadrant were harvested, counted and the mean recorded per meter squared (m<sup>2</sup>). For weed dry matter, the harvested weeds were enveloped according to treatments and oven dried at 70 °C to a constant weight and the values expressed in grammes m<sup>-2</sup>. Cassava tuberous roots were manually harvested at 12 months after planting (MAP), and fresh

root tuber yield determined by weighing all the tubers from the plants within the net plot using a 20 kg top loading spring balance (Model: SP20KG; Manufacturer: Hana Scales, China), and the means expressed in kilograms per plant and tonnes per hectare. Data collected were subjected to analysis of variance (ANOVA) procedures for factorial experiments in randomized complete block design (RCBD) using the GenStat Package Version 8.1 of 2015. Means were compared using the Fisher's least significant difference (FLSD) method at 5% level of probability.

**Results and Discussion****Effects of polyethylene sheet colour and *in situ* solarization duration on weed density and weed dry matter**

The effects of polyethylene sheet colour, *in situ* solarization duration and their interactions on weed density and weed dry matter in cassava plots in 2019 and 2020 cropping seasons are shown in Tables 1 and 2, respectively. Weed density and weed dry matter were not significantly ( $p > 0.05$ ) affected by polyethylene sheet colour at all sampling periods in both years. The similarity in weed density and weed dry matter between the black and white polyethylene treatments indicates that both colours of polyethylene had similar potentials to effectively suppress weeds, supporting the findings of Nwagwu *et al.* (2022), who reported similar two-year combined mean weed density and combined mean weed dry matter in maize plots solarized with black, green and white polyethylene films in the same study area.

*In situ* solarization duration significantly ( $p < 0.05$ ) influenced weed density and weed dry matter at all sampling periods in both years, with solarized plots having significantly ( $p < 0.05$ ) lower weed density and weed dry matter values compared with the non-solarized control. Quantitatively, *in situ* solarization reduced weed density by

92.86 % and weed dry matter by 95.02 % on the two-year average. This indicates highly efficient weed control with the use of polyethylene sheets, due to its heat transmitting effect on the soil. This finding corroborates the report of Jacobs *et al.* (2019), who obtained a 95.2 % weed dry matter reduction in organic strawberry production in California by plastic mulching. It has been reported that plastic mulch can completely suppress weeds in cassava fields (Golzardi *et al.*, 2014), due to its ability to inhibit weed seedling emergence (Nedunchezhiyan *et al.*, 2017). During

solarization, high heat is generated which becomes lethal to weed seeds and seedlings (Pathel *et al.*, 2005), thus leaving little or no chance for the germination and establishment of weeds. Also, it is possible that a high carbon (iv) oxide accumulation under the plastic sheets during solarization may have induced dormancy in the weed propagules causing them to fail to germinate throughout the period of cover. Significant weed density and weed dry matter reduction by plastic mulching has been reported in cassava (Aniekwe *et al.*, 2004) and sweet potato (Laurie *et al.*, 2015).

Table 1: Effects of polyethylene sheet colour and *in situ* solarization duration on weed density

Treatment	Weed density (no m <sup>-2</sup> )							
	2019				2020			
	Weeks After Planting							
	4	8	12	Mean	4	8	12	Mean
Polyethylene sheet colour								
Black (B)	16.80	26.40	43.00	28.73	17.00	30.30	44.90	30.73
White (W)	18.20	27.10	44.10	29.80	16.20	30.40	46.40	31.00
LSD <sub>(0.05)</sub>	NS	NS	NS	NS	NS	NS	NS	NS
Solarization Duration								
S <sub>0</sub>	62.80	109.00	162.00	111.27	65.20	122.00	170.00	119.07
S <sub>1</sub>	7.00	8.00	24.30	13.10	5.50	11.20	29.20	15.30
S <sub>2</sub>	6.50	6.20	14.50	9.07	4.30	6.80	12.00	7.70
S <sub>3</sub>	6.70	5.50	8.80	7.00	3.70	6.20	8.00	5.97
S <sub>4</sub>	4.50	5.20	8.00	5.90	4.30	5.70	9.00	6.33
LSD <sub>(0.05)</sub>	10.43	15.02	17.47	14.31	12.83	13.13	12.77	12.91
Interaction								
BS <sub>0</sub>	62.30	107.30	161.70	110.43	67.30	124.30	169.70	120.43
BS <sub>1</sub>	6.30	6.30	23.30	11.97	5.70	9.30	26.70	13.90
BS <sub>2</sub>	5.70	6.70	14.00	8.80	3.70	7.00	11.70	7.47
BS <sub>3</sub>	6.30	5.00	7.30	6.20	3.30	6.30	7.30	5.63
BS <sub>4</sub>	3.30	6.70	8.70	6.23	5.00	4.70	9.00	6.23
WS <sub>0</sub>	63.30	110.70	162.30	112.10	63.00	119.70	170.30	117.67
WS <sub>1</sub>	7.70	9.70	25.30	14.23	5.30	13.00	31.70	16.67
WS <sub>2</sub>	7.30	5.70	15.00	9.33	5.00	6.70	12.30	8.00
WS <sub>3</sub>	7.00	6.00	10.30	7.77	4.00	6.00	8.70	6.23
WS <sub>4</sub>	5.70	3.70	7.30	5.57	3.70	6.70	9.00	6.47
LSD <sub>(0.05)</sub>	14.74	21.24	24.71	20.23	18.14	18.57	18.06	18.26

NS = Not significant; S<sub>0</sub> = No solarization; S<sub>1</sub> = *in situ* solarization for 8 weeks

S<sub>2</sub> = *in situ* solarization for 12 weeks; S<sub>3</sub> = *in situ* solarization for 16 weeks

S<sub>4</sub> = *in situ* solarization for 48 weeks (till harvest)

Table 2: Effects of polyethylene sheet colour and *in situ* solarization durations on weed dry matter

Treatment	Weed dry matter (g m <sup>-2</sup> )							
	2019				2020			
	Weeks After Planting			Mean	Weeks After Planting			Mean
4	8	12	4		8	12		
Polyethylene sheet colour								
Black (B)	6.60	14.30	23.30	14.73	6.50	16.60	24.50	15.87
White (W)	6.20	14.80	25.20	15.40	6.60	17.00	29.30	17.63
LSD <sub>(0.05)</sub>	NS	NS	NS	NS	NS	NS	NS	NS
Solarization Duration								
S <sub>0</sub>	22.30	63.50	106.40	64.07	24.90	71.80	110.20	68.97
S <sub>1</sub>	3.10	2.50	5.80	3.80	2.40	4.30	11.60	6.10
S <sub>2</sub>	2.40	3.00	3.80	3.07	1.80	2.70	6.10	3.53
S <sub>3</sub>	2.70	2.10	2.90	2.57	1.60	2.60	4.10	2.77
S <sub>4</sub>	1.50	1.80	2.10	1.80	1.90	2.40	4.60	2.97
LSD <sub>(0.05)</sub>	5.36	5.96	11.09	7.47	6.07	8.71	9.64	8.14
Interaction								
BS <sub>0</sub>	23.20	63.40	103.70	63.43	25.40	72.50	105.90	67.93
BS <sub>1</sub>	3.20	1.70	4.70	3.20	2.30	3.60	7.90	4.60
BS <sub>2</sub>	2.20	3.90	2.90	3.00	1.50	2.60	5.80	3.30
BS <sub>3</sub>	2.50	1.50	2.80	2.27	1.30	2.40	3.00	2.23
BS <sub>4</sub>	1.80	0.90	2.20	1.63	2.10	2.00	4.10	2.73
WS <sub>0</sub>	21.40	63.50	109.20	64.70	24.50	71.00	114.50	70.00
WS <sub>1</sub>	3.00	3.30	6.90	4.40	2.60	5.10	15.30	7.67
WS <sub>2</sub>	2.60	2.10	4.70	3.13	2.20	2.80	6.40	3.80
WS <sub>3</sub>	2.80	2.60	3.10	2.83	1.90	2.70	5.20	3.27
WS <sub>4</sub>	1.10	2.70	2.00	1.93	1.80	2.80	5.00	3.20
LSD <sub>(0.05)</sub>	7.58	8.42	15.69	10.56	8.58	12.32	13.64	11.51

NS = Not significant; S<sub>0</sub> = No solarization; S<sub>1</sub> = *in situ* solarization for 8 weeks

S<sub>2</sub> = *in situ* solarization for 12 weeks; S<sub>3</sub> = *in situ* solarization for 16 weeks

S<sub>4</sub> = *in situ* solarization 48 weeks (till harvest).

Weed populations in the solarized plots were statistically ( $p > 0.05$ ) similar across solarization durations at all sampling periods, except at 12 WAP in both years, when *in situ* soil solarization for 8 weeks was significantly ( $p < 0.05$ ) higher than other durations. This finding indicates that plastic mulching can be effective against weed propagules in cassava field if left *in situ* for 8 weeks or longer. Similar findings have been reported that soil solarization for 6 and 9 weeks resulted in

substantial weed density and weed dry matter reductions in maize (Nwagwu *et al.*, 2022, Nwagwu *et al.*, 2023 a) and carrot (Marenco & Lustosa, 2000), respectively.

There were significant interactions of polyethylene sheet colour and *in situ* soil solarization duration on weed density and weed dry matter at all sampling periods in both years. Significantly ( $p < 0.05$ ) highest weed density and weed dry matter were consistently recorded in the non- solarized

control relative to the solarized plots, within the sheet colour and soil solarization duration interactions. This finding implies that *in situ* solarization was equally effective in each colour and duration combination in all solarized plots, which corroborates the results of Nwagwu *et al.* (2022) who reported significant interactions among polyethylene colours and mulching durations in maize field.

### **Effects of polyethylene sheet colour and *in situ* solarization duration on vegetative performance of cassava**

The effects of polyethylene sheet colour, *in situ* soil solarization duration and their interactions on plant height and number of leaves per plant are presented in Table 3. Sheet colour did not significantly ( $p > 0.05$ ) influence plant height and number of leaves per plant at all sampling periods in both years, except plant height at 12 WAP in 2020. The similarity in the growth performance of cassava under black and white polyethylene at most sampling periods could be attributed to the relative effectiveness of the polyethylene sheets in weed suppression, thereby conserving nutrients for the crop to utilize. Stapleton *et al.* (1989) also reported similarity in the performance of crops under black and transparent polyethylene film mulches.

*In situ* soil solarization duration significantly ( $p < 0.05$ ) influenced plant height at all sampling periods, except at 4 WAP in both years. Similarly, the number of leaves per plant was significantly affected by solarization at all sampling periods in both years. Across solarization durations in both years, cassava was significantly ( $p < 0.05$ ) taller and produced significantly ( $p < 0.05$ ) higher number of leaves in solarized plots

relative to the non-solarized control treatment.

This is reflective of the weed suppressive potential of the polyethylene sheets compared with the plots without solarization. The drastic reduction in weed pressure in the solarized plots must have translated to higher amounts of the growth factors especially mineral nutrients and water being available to, and utilized by the crops, in the near total absence of weeds in those treatments. This finding is in line with the works of Otoo (1985) and Aniekwe *et al.* (2004) who recorded a general improvement of the growth parameters of cassava under *in situ* solarization.

Conversely, the shorter stems and lower number of leaves in the non-solarized plots can be attributed to the relatively higher weed pressure in those treatments as indicated by the significantly higher density and dry weight of weeds in the plots without solarization. The higher weed density and weed dry matter in the non-solarized treatment invariably resulted in greater weed competition, thereby leading to reduced vegetative performance of cassava. This finding is consonant with that of Nwagwu *et al.* (2023a), who recorded reduced growth performance of hybrid maize in non-solarized treatments compared with solarized plots.

There were no significant ( $P > 0.05$ ) differences in plant height and the number of leaves per plant among the solarized plots at all sampling periods in both years. This finding indicates that all the *in situ* solarization durations (56 - 336 days) were equally effective in enhancing the vegetative performance of cassava; and this is attributed to the similarity in effective weed suppression among the solarized plots.

Table 3: Effects of polyethylene sheet colour and *in situ* solarization durations on plant height(cm) and number of leaves per plant

Treatment	Plant height (cm)						Number of leaves plant <sup>-1</sup>					
	2019 WAP			2020			2019 WAP			2020		
	Weeks After Planting			Weeks After Planting			Weeks After Planting			Weeks After Planting		
	4	12	20	4	12	20	4	12	20	4	12	20
<b>Polyethylen sheet colour</b>												
Black (B)	13.60	115.90	193.50	20.70	117.30	195.20	12.00	45.30	73.90	15.10	55.80	78.10
White (W)	13.70	107.50	187.60	20.90	110.30	188.70	12.50	40.00	73.00	15.70	51.60	75.80
LSD <sub>(0.05)</sub>	NS	NS	NS	NS	6.58	NS	NS	NS	NS	NS	NS	NS
<b>Solarization duration</b>												
S <sub>0</sub>	11.20	80.70	153.20	19.70	86.30	146.30	10.50	35.20	56.50	14.30	43.80	53.70
S <sub>1</sub>	15.20	113.30	196.30	21.00	117.70	189.80	12.50	41.20	72.00	14.80	53.50	76.20
S <sub>2</sub>	14.20	114.20	199.50	20.70	117.70	197.80	12.20	41.80	75.20	15.70	51.30	82.30
S <sub>3</sub>	14.30	128.70	201.50	20.70	124.50	210.50	13.00	41.20	80.30	14.80	58.30	84.20
S <sub>4</sub>	13.50	121.70	202.20	22.00	122.80	215.30	13.20	46.30	83.20	17.30	61.50	88.50
LSD <sub>(0.05)</sub>	NS	18.72	30.76	NS	10.37	14.80	1.89	7.16	13.94	2.27	10.84	5.97
<b>Interaction</b>												
BS <sub>0</sub>	10.30	79.30	156.70	21.00	89.00	142.30	9.30	35.00	54.70	15.00	44.00	50.30
BS <sub>1</sub>	14.70	121.30	199.00	20.70	125.30	196.70	12.30	45.30	74.30	13.30	55.00	78.00
BS <sub>2</sub>	14.70	121.70	202.70	17.70	117.70	203.70	12.30	50.00	70.00	15.00	55.30	85.70
BS <sub>3</sub>	14.70	138.70	205.00	21.70	126.70	212.30	12.30	47.00	86.00	15.00	56.30	86.00
BS <sub>4</sub>	13.70	118.70	204.00	22.70	127.70	221.00	13.70	49.00	84.30	17.00	68.30	90.70
WS <sub>0</sub>	12.00	82.00	149.70	18.30	83.70	150.30	11.70	35.30	58.30	13.70	43.70	57.00
WS <sub>1</sub>	15.70	105.30	193.70	21.30	110.00	183.00	12.70	37.00	69.70	16.30	52.00	74.30
WS <sub>2</sub>	13.70	106.70	196.30	23.70	117.70	192.00	12.00	42.70	80.30	16.30	47.30	79.00
WS <sub>3</sub>	14.00	118.70	198.00	19.70	122.30	208.70	13.70	41.30	74.70	14.70	60.30	82.30
WS <sub>4</sub>	13.30	124.70	200.30	21.30	118.00	209.70	12.70	43.70	82.00	17.70	54.70	86.30
LSD <sub>(0.05)</sub>	NS	26.47	43.49	4.98	14.67	20.93	2.67	10.13	19.72	3.21	15.33	8.44

NS = Not significant; S<sub>0</sub> = No solarization; S<sub>1</sub> = *in situ* solarization for 8 weeks

S<sub>2</sub> = *in situ* solarization for 12 weeks; S<sub>3</sub> = *in situ* solarization for 16 weeks

S<sub>4</sub> = *in situ* solarization 48 weeks (till harvest).

There were significant interactions of polyethylene sheet colour and *in situ* soil solarization duration on cassava plant height and number of leavers per plant at all sampling periods in both years. Significantly ( $p < 0.05$ ) tallest plants and highest number of leaves per plant were produced by cassava in the solarized plots irrespective of polyethylene sheet colour and *in situ* soil solarization duration, compared with the non-solarized plots, while the shortest plants and least number of leaves per plant were

recorded in plots not solarized, irrespective of duration. This finding underscores the similar high potential of black and transparent polyethylene in enhancing cassava growth characteristics through effective weed suppression.

### Effects of polyethylene sheet colour and *in situ* solarization durations on cassava root tuber yield

The effects of polyethylene sheet colour, *in situ* soil solarization duration and their interactions on cassava root tuber yield per plant and per hectare are shown in Table 4. The root tuber yield per plant and per hectare were not significantly ( $p > 0.05$ ) influenced by polyethylene sheet colour. This could be attributed to the similarity in weed suppression and vegetative performance of cassava under both black and white polyethylene sheets. The results of Stapleton *et al.* (1989) found similarity in crop performance under black and white polyethylene film mulches. Similarly, Nwagwu *et al.* (2022) found no significant differences in a two-year mean 1000-grain weight of maize under black and transparent white polyethylene. On the contrary, Nwagwu *et al.* (2023a) reported better vegetative growth and yield of maize under white polyethylene mulch than black polyethylene mulch.

Cassava tuber yield was significantly ( $p < 0.05$ ) influenced by *in situ* soil solarization duration and the interactions between the factors in both years. Generally, the solarized plots yielded significantly higher fresh tuber yields per plant and on per hectare basis in comparison with the non-solarized treatment. Averaged over both years, *in situ* solarization resulted in 94.62 % and 97.61 % in cassava fresh root tuber yield per plant and per hectare, respectively. This is attributed to the highly efficient ( $> 90$  %) weed suppression by the polyethylene sheets in the solarized plots coupled with possible modification of the soil rhizosphere by *in situ* solarization, which led to superior vegetative performance and ultimately higher yield of cassava. This finding is consistent with those of previous

researchers (Marenco & Lustosa, 2000; Nwagwu *et al.*, 2022; Nwagwu *et al.*, 2023b). Furthermore, cassava tuber yield increased with increasing *in situ* solarization duration, with maximum yield ( $64.15 \text{ t ha}^{-1}$ ) obtained from plots solarized till harvest (48 weeks).

This could be as a result of prolonged weed control in the plots solarized till harvest, which ensured more nutrient and water availability to the cassava plant than in shorter treatments. Previous findings indicated crop yield increased with increasing soil solarization or plastic mulch durations from 4-10 weeks in cassava (Umunnakwe *et al.*, 2023c), and from 2 to 6 weeks in okra (Seman-Varner *et al.*, 2008). Similarly, season-long mulching with polyethylene sheets significantly increased yields in sweet potato (Jiang *et al.*, 2014) and maize (Nwagwu *et al.*, 2023a). The progressive decline in root tuber yield of cassava as *in situ* solarization duration shortened could be attributed to resumed weed completion after the removal of the polyethylene sheets. Cassava is a long gestation annual crop (12 months or above). It is likely that weeds which emerged between 16 and 32 WAP following the removal of the polyethylene sheets in the shorter *in situ* solarization duration (8-16 weeks) plots continued competing for water and nutrients, and might have interfered with tuber bulking, leading to lower tuber yields. This is consistent with the findings of Onochie (1975) who reported that weed competition after 4 months in cassava still reduced cassava root tuber bulking and overall tuberous yield in cassava. Similar trends were reported in maize yield under different solarization durations in the same study area (Nwagwu *et al.*, 2022; Nwagwu *et al.*, 2023a).

Table 4: Effects of polyethylene sheet colour and *in situ* solarization durations on cassava root tuber yield

Treatment	Cassava tuber yield					
	Yield per plant (kg)		Mean	Yield (t ha <sup>-1</sup> )		
	2019	2020		2019	2020	Mean
Black (B)	4.60	4.40	4.50	46.10	44.40	45.25
White (W)	4.50	4.70	4.60	45.30	46.50	45.90
LSD <sub>(0.05)</sub>	NS	NS	NS	NS	NS	NS
Solarization						
Duration						
S <sub>0</sub>	2.50	2.70	2.60	24.70	26.50	25.60
S <sub>1</sub>	4.20	4.20	4.20	41.50	41.50	41.50
S <sub>2</sub>	4.60	4.30	4.45	46.20	43.00	44.60
S <sub>3</sub>	5.10	5.30	5.20	51.20	53.00	52.10
S <sub>4</sub>	6.50	6.30	6.40	65.00	63.30	64.15
LSD <sub>(0.05)</sub>	0.64	0.86	0.75	6.44	8.56	7.50
Interaction						
BS <sub>0</sub>	2.30	2.70	2.50	23.00	27.30	25.15
BS <sub>1</sub>	4.10	3.90	4.00	41.00	39.00	40.00
BS <sub>2</sub>	4.90	4.20	4.55	49.30	41.70	45.50
BS <sub>3</sub>	5.20	5.00	5.10	52.30	50.30	51.30
BS <sub>4</sub>	6.50	6.40	6.45	65.00	63.70	64.35
WS <sub>0</sub>	2.60	2.60	2.60	26.30	25.70	26.00
WS <sub>1</sub>	4.20	4.40	4.30	42.00	44.00	43.00
WS <sub>2</sub>	4.30	4.40	4.35	43.00	44.30	43.65
WS <sub>3</sub>	5.00	5.60	5.30	50.00	55.70	52.85
WS <sub>4</sub>	6.50	6.30	6.40	65.00	63.00	64.00
LSD <sub>(0.05)</sub>	0.91	1.21	1.06	9.10	12.11	10.605

NS = Not significant; S<sub>0</sub> = No solarization; S<sub>1</sub> = *in situ* solarization for 8 weeks

S<sub>2</sub> = *in situ* solarization for 12 weeks; S<sub>3</sub> = *in situ* solarization for 16 weeks

S<sub>4</sub> = *in situ* solarization 48 weeks (till harvest).

The lowest tuber yields of cassava were obtained from the non-solarized control plots, which is attributable to the high weed infestation and reduced vegetative performance of cassava in those treatments. Weed density is known to have a sigmoid relationship with crop yield, reducing yield after a certain critical population. In the case of weed dry matter, the effect on crop yield is a linear inverse relationship. Every increase in weed dry matter proportionately reduces crop yield potentially (DAS, 2013). Therefore, the non-solarized plots which had the highest weed density and highest weed dry matter

performed poorly in the growth and yield of cassava compared with the solarized treatments.

The interaction of polyethylene sheet colour and *in situ* solarization duration indicated that the highest tuber yields per plant and per hectare were obtained from plots solarized till harvest (48 weeks) with white or black polyethylene sheets.

## Conclusion

Conclusively, the results demonstrate that *in situ* solarization effectively suppressed weeds and enhanced the vegetative and yield performance of cassava far above the farmer's practice of leaving the soil bare. It is therefore recommended that, for optimum cassava yield, farmers in the study area and its environs can employ the use of white or black polyethylene sheets as *in situ* solarization (polyethylene mulch) for a period of 48 weeks in cassava fields.

## References

- Albuquerque, J. A. A., Sedyama, T., Silva, A. A., Alves, J. M. A., Finoto, E. L., Neto, F. A. & Silva, G. R. (2012). Development of cassava crop under weed interference. *Planta Daninha*, 30(1), 37 – 45.
- Aniekwe, N. L., Okereke, O. U. & Anikwe, M. A. N. (2004). Modulating effect of black plastic mulch on the environment, growth and yield of cassava in a derived Savanna Belt of Nigeria. *Tropicultura*, 22(4), 185 – 190.
- Efiong, J. (2011). Changing pattern of land use in Calabar River catchment, southeastern Nigeria. *Journal of Sustainable Development*, 4(1), 92 – 102.
- Das, T. K. (2013). *Weed Science: Basics and Applications*. Jain Brothers New Delhi.
- FAO (Food and Agriculture Organization of the United Nations) (2025). *FAOSTAT: Crops and livestock products database (2023 data release)*. Rome, Italy: FAO. Retrieved June 22, 2026.
- Golzardi, F., Vaziritabar, Y., Vaziritabar, Y., Sarvaramini, S. & Ebadi, S. Z. (2014). Solarization period and thickness of polyethylene sheet effects on weed density and biomass. *Indian Journal of Fundamental and Applied Life Sciences*, 4(3), 587 – 593.
- IITA - International Institute of Tropical Agriculture (2017). Cassava weed management project. [www.cassavaweed.org](http://www.cassavaweed.org). Retrieved 9<sup>th</sup> June 2020.
- Jacobs, T., Tubeileh A. & Steinmaus, S. (2019). Effect of Sudan grass cover crop residues and soil solarization on weed and *Verticillium dahlia* populations in organic strawberry production. 2019 American Society of Horticultural Science annual conference. Las Vegas, July 21 – 25, 2019.
- Jiang, Y., Shi, C., Wang, Z., Wang, C. & Liu, H. (2014). Effects of plastic film mulching on arable layer soil temperature, moisture and yield of sweet potato. *Chinese Journal of Eco-Agriculture*, 22(6), 627- 634.
- Laurie, S. M., Maja, M. N., Ngobeni, H. M. & Du-Plooy, C. P. (2015). Effect of different types of mulching and plant spacing on weed control, canopy cover and yield of sweet potato (*Ipomoea batatas* (L.) Lam). *American Journal of Express Agriculture*, 5, 450 – 458.
- Marenco, R. A., & Lustosa, D. C. (2000). Soil solarization for weed control in carrot. *Agricultural species Bras, Brasilia*, 35(10), 2025-2032.
- Melifonwu, A., James, B., Aihou, K., Weise, S., Awah, E. & Gbaguidi, B. (2000). *Weed control in cassava farms: IPM Field Guide*. Wordsmithes Printers, Lagos. Pp 1-23.
- Nedunchezhiyan, M., Byju, G., Veena S. S. & Ravi, V. (2017). Herbicides and polyethylene sheet mulching effects on yield of cassava. *Indian Journal of Weed Science*, 49(1), 58 – 62.
- Nwagwu, F. A., Umunnakwe. O. C., Uko, A. E., & Otumadu, G. E. (2022). Weed population and biomass as influenced by polyethylene film colour and soil solarization duration in maize (*Zea mays* L.) field. *Journal of Agriculture, Forestry and Environment*, 6(1), 13-24.

- Nwagwu, F. A., Obok, E. E., Umunnakwe, O. C. & Akpan, J. F. (2023a). Influence of polyethylene film colour and soil solarization duration on weed dynamics and performance of hybrid maize (*Zea mays* L.). *International Journal of Agricultural Technology*, 19(2):555-580.
- Nwagwu, F. A., Ojikpong, T. O. & Umunnakwe, O. C. (2023b). Effect of polyethylene sheet colour and *in situ* solarization durations on the phytosociological structures of the predominant weeds in humid environment of southern Nigeria. *Journal of Bangladesh Agricultural University*, 21(2): 161-167.
- Nzeako, E. N., Udensi, U. E., Omovbude, S. & Orluchukwu, J. A. (2019). maize and weed response to legume cover short fallow and fertilizer in Port Harcourt South Eastern Nigeria. *Journal of Applied Life Sciences International*, 20(2), 1-13. DOI: 10.9734/JALSI/2019/v20i230078
- Omovbude, S., Oroka, F. O. & Udensi, E. U. (2017a). Effect of different weed control practices on proximate composition, nutrient concentration and uptake of maize (*Zeamays* L.). *IOSR Journal of Agriculture and Veterinary Science*, 10(2), 91-104. [https://doi.org/ 10.9790/2380-10020198104](https://doi.org/10.9790/2380-10020198104)
- Omovbude, S., Udensi, E. U. & Orluchukwu, J. A. (2017b). Weed suppression and maize yield engendered by intercropping in the humid forest agro-ecology of South-Eastern Nigeria. *Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, 10(9): 40-46. DOI:10.9790/2380-1009024046 (e-ISSN: 2319-2380, p-ISSN: 2319-2372, [www.iosrjournals.org](http://www.iosrjournals.org))
- Onasanya, O. O., Hauser, S., Necpalova, M., Salako, F. K., Kreye, C., Tariku, M., Six, J. & Pypers, P. (2021). On-farm assessment of cassava root yield response to tillage, plant density, weed control and fertilizer application in southwestern Nigeria. *Field Crops Research*, 262, 1 – 9.
- Onochie, B. E. (1975). Critical periods of weed control in cassava in Nigeria. *PANS*, 2(1), 54-57.
- Otoo, J. A. (1985). Effect of plastic mulch on growth and tuber yield of cassava. In: Nationally coordinated research project on cassava research report, edited by Okeke J.E., Root Crops Research Institute, Umudike, Umuahia, Nigeria.
- Pathel, R. H., Shroff, J., Duta, S., & Meisher, T. (2005). Weed dynamics as influenced by solarization. *Journal of Agriculture Review*, 26(4), 295-300.
- Seman-Varner, R., McSorley, R., & Gallaher, R. N. (2008). Soil nutrient and Plant responses to solarization in an agroecosystem utilizing an organic nutrient source. *Renewable Agriculture and Food Systems*, 23(2), 149-154, DOI:10.1017/S1742170507002001.
- Stapleton, J. J., Asai, W. K., & DeVey, J. E. (1989). Use of polymer mulches in irrigated pest management programmes for establishment of perennial fruit crops. *ActaHorticulturae*, 255, 161-166.
- Udensi E. U., Tarawali, G., Ilona, P., Okoye, B. C., & Dixon, A. (2012). Adoption of chemical weed control among cassava farmers in South-Eastern Nigeria. *Journal of Food, Agriculture & Environment*, 10(1), 667-674 (FINLAND)
- Udensi U. E., Umunnakwe, O. C., & Gworgwor, N. A. (2025). Weed management strategies: Looking beyond the 21st Century and the implications on sustainable productivity and food security. In U. Zakka, A. A. Aiyeloja, O. M. Adesope and O. Lawal (Eds.), *Building a sustainable foundation for*

- 21<sup>st</sup> century agricultural advancement (pp. 255-269). Academic Press.
- Umunnakwe, O. C., Nwagwu, F. A., Ojikpong, T. O., Awelewa, E. A., & Ebri, B. O. (2023a). Influence of cassava and turmeric intercropping system on phytosociology of predominant weeds in Calabar. *Nigerian Agricultural Journal*, 54(1), 42 - 48.
- Umunnakwe, O. C., Nwagwu, F. A., Onen, B. E., Ekeruke, A. N. & Awelewa, E. A.(2023b). Phytosociological characteristics of the predominant weeds in Calabar, as influenced by cassava density and soil solarization duration. *Journal of Agriculture and Environment*, 19(1), 145 - 164.
- Umunnakwe, O. C., Akpan, J. F., Omadewu, L. I., Bisong, O. B., Awelewa, E. A., & Onen, B.E. (2023c). Economics of cassava (*Manihot esculenta* Crantz) cultivation under varying planting densities and pre-planting soil solarization duration. *Journal of Bangladesh Agricultural University*, 21(4), 414 – 420.<https://doi.org/10.5455/JBAU.159806>