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RESEARCH ARTICLE

EVALUATION OF WEED SUPPRESSIVE ABILITY OF DIFFERENT DEAD MULCH MATERIALS FOR WEED CONTROL IN A CELOSIA (*CELOSIA ARGENTEA* L.) PLOT IN SOUTHERN NIGERIA

***Omovbude, S., Ogbonna, N.U. and Benwari, A.O.**

Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, P. M. B. Choba Port Harcourt, Rivers State, Nigeria

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ABSTRACT

This study was conducted to evaluate the weed suppressive ability of different dead mulch materials for weed control in the production of celosia(Celosia argentea L.) at the Faculty of Agriculture Teaching and Research Farm of the University of Port Harcourt, Choba, Rivers State, Nigeria in a humid forest agro-ecology between April and July, 2012.Theexperiment consisted of six (6) treatments namely: calapo mulch, guinea grass mulch, sawdust mulch, wood shavings mulch, hoe weeding at 3 &7 weeks after planting (WAP)(control) and no weeding(control).The 6treatments were laid out in a randomized complete block design(RCBD) with four replicates. Results showed that no weeding plot was consistent in recording the highest weed growth characteristics in terms of weed density throughout the five (5) periods of sampling, weed fresh and dry weight at final harvests. Manualhoe weeding at 3 and 7 WAP was significantly ($p<0.05$) more efficient in controlling weeds followed by wood shavings mulch, sawdust mulch, calopo mulch and then guinea grass mulch. In terms of celosia growth characteristics, calapo mulch performed best at 8WAP by producing the highest shoot height (93.33cm), stem girth (3.25cm) number of leaves (64.25), leaf area (79.78cm2) and marketable fresh shoot yield (425,111.11 kg/ha) while, no weeding (control) had the lowest of the growth and yield parameters assessed. Relative to the unweeded (control) mulching increased celosia shoot marketable yield by 2,485.14% (calopo mulch), 121.62% (Two –hoe weeding @ 3 & 7WAP), 70.27%, (guinea grass mulch), 50% (wood shaving mulch) and 25.68 % (saw dust mulch).Partial farm budget analysis showed that among the treatments used, calopo mulch application had the highest net return (profit) of ₦85007222/ha and cost- benefit ratio(CBR)of 1:5667.15whichtherefore,implies that it is more profitable to control weeds with calapo mulchin the area of study.

INTRODUCTION

Celosia **(***Celosia argentea* L.) also known as Lagos Spinach (Badra, 1991), is a leafy vegetable crop belonging to the family Amaranthaceae, a versatile herbaceous plant characterized by its fast growth. It is widely cultivated in tropical and subtropical regions (Grubben, 1977). The crop is popular in South Western Nigeria due to the softness of the leaf texture, popularly called ‘’Sokoyokoto’’ by the Yorubas (Schippers, 2000). It is well distributed and consumed in Nigeria where it is regarded as a vegetable of national importance (NIHORT, 1986). The vegetable is accredited with possession of high nutritional values of essential nutrients like calcium, phosphorus, iron and other important components such as vitamin C, fiber, carbohydrate, fat and high calorific value (Badra, 1991). Its leaves and young shoots are used in soup and stews; the leaves can be slightly mucilaginous. Boiled shoots are served with carbohydrate foods such as yam or yam flour, rice etc. (Babajide *et al.,* 2012). Schippers (2000) reported that the vegetable contains high level of protein with C_3 cycle of photosynthesis which allows it to perform optimally under partly shaded conditions. He also noted that its uses are beyond dietary and extend to medicinal purposes and treatment of ailments such as abscesses, cough, diabetes, diarrhea, dysentery, eczema, eye problems, gonorrhea, infected sores, liver ailments, menstruation problems, muscle troubles, skin eruptions, snakebites and wounds. Despite the usefulness of this vegetable, weeds constitute a major impediment to its production in Nigeria. Usoroh *et al*. (1985) noted that the first four weeks after planting is regarded to be to be the critical period of weed interference in celosia production. Okhira *et al., (*1992) reported yield reduction of 50.39% of celosia under complete weedy situation (no weeding) when compared with maximum yield under dry legume plots. They also noted yield

****Corresponding author: Omovbude, S.,***
Department of Crop and Soil Science, Faculty of Agriculture, University of Port Harcourt, P. M. B. Choba Port Harcourt, Rivers State, Nigeria.

reduction of 61.27% of the vegetable under complete weedy situation when compared with the appropriate maximum yield under weed free condition .Other similar reports on fruit and leafy vegetables by other researchers showed percentage yield reduction. For instance, In Nigeria uncontrolled weeds caused yield reduction ranging from 53 .95% in pepper (Adigun *et al.,* 1983) and 88% to 90% in okra (Adejonwo *et al.,* 1989). The traditional farmers in Nigeria control weeds in celosia's farm either by manual hoe weeding or by herbicides application. However, both methods had their short comings. Hoe weeding is not only slow and laborious, but often difficult at peak period primarily as a result of population drift byable-bodied young youths from rural to urban areas. When carelessly used, the hoe causes loss. The use of herbicide has shown a lot of promise in weed control (Aliyu and Lagoke, 1995). However, the practice does not adequately control weeds attimes as result of weed resistant to constant and prolonged use of herbicide, may be adulterated making it ineffective against weeds, may produce residual contaminants, and may cause phytotoxicity to crop plants as result of poor sprayer calibration, faulty equipment or failure to follow label directions and special skills are required to use herbicide successfully (Akobundu, 1987; Aliyu and Lagoke, 1995; Smith and Ayenigbara, 2003). Thus**,** other alternative methods of weed control such as the use of mulching are required. Incorporation of mulches to the soil has a number of agronomical benefits such as suppressing weed growth, increasing organic matter contents, increasing nutrient availability to crops, reducing the surface run-off and improving the moisture retaining capacity of the soil that improves nutrient availability of the plants and maintaining soil fertility in agricultural lands, particularly in areas where application of fertilizer is expensive (Weerakon and Senewirantne, 1984). Although, it is agronomical sound to add organic matter to the soil by dead mulches. Its economic returns had to be addressed because neither the material nor application itself is free of monetary charges. Information on the use of dead mulch materials for weed control in celosia vegetable in Nigeria are scanty although its application has been gradually expanding. The few reports on dead mulch materials for weed control are those of Okhiria *et al.,* (1992). Hence, the objective of the study was to evaluate the effect of some dead mulch materials on weed suppression, growth and yield of celosia production in Southern Nigeria.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Teaching and Research Farm of the University of Port Harcourt, Choba, Rivers State, Nigeria between April and July, 2012, in a humid forest agro-ecology with latitude 04^{o} 54^{I} 538^{I}N and longitude 006^{0} 55^{I} 329^{I}E with an elevation of 17metres above sea level. The area experiences distinct wet (April to November) and dry (December to March) seasons. The experimental site was left fallow for two years before the commencement of the study. The vegetation was dominated by weeds such as C*hromolaena odorata*, *Aspilia africana*, C*ommelina benghalensis*, *Panicum maximum* and *Cyperus* spp.

Soil analysis

Prior to and after planting, representative soil samples were taken randomly from the experimental plot at uniform depth of 0-15cm with an auger for physico-chemical properties. These properties were determined by standard laboratory procedures. Particles size distribution was determined by the hydrometer method (Gee and Bauder, 1982), P^{H} is a 1:2 soil : water ratio (Mclean, 1982), , organic carbon /organic matter with wet oxidation method (Nelson and Sommers, 1982), total nitrogen was determined by the Keeney and Nelson (1987) method while available phosphorus was determined by rapid perchloric acid digestion method (Alder,1995), calcium was determined by atomic absorption spectrophotometry while potassium (K) was by flame photometry (Tan, 1996).

Source of planting material

Seeds of *Celosia argentea*, variety "TLV8' (Tropical leafy vegetable with number 8)were obtained from the National Institute for Horticultural Research (NIHORT), Ibadan, Nigeria.

Source of mulch materials and analysis

The calopo (*Calopogonium mucunoide*s Desv.) and guinea grass (*Panicum maximum* Jacq)used for the study were harvested before flowering at the University of Port Harcourt environment and sun dried to a constant weight while the sawdust mulch and wood shavings mulch were obtained from sawmill factory at Rumuosi Town, close to University of Port Harcourt. The mulch materials were analyzed by AOAC (1990) method before application.

Experimental Design, Treatment and Cultural Details

The land was manually cleared and debris was packed. The experiment was a Randomized Complete Block Design (RCBD) with six (6) treatments namely: calopo (10t/ha), guinea grass (10t/ha), sawdust mulch (10t/ha), wood shavings mulch (10t/ha), hoe weeding twice at 3&7 WAP (control) and unweeded (control). The six treatments were replicated four times. The spacing used was 30cm between rows and 15cm within rows. Each plot measured 1.5m x 2.4m with alley ways of 1m each between plots and replicates. There were a total of twenty four (24) beds raised to a height of 30cm per plot occupying an area of approximately 0.02ha the dead mulch materials were spread per plot at a thickness of 2cm before planting leaving a little opening for seed germination. Celosia seeds were sown on 25^{th} of April 2012 at two seeds per hole. The seedlings were later thinned to one per stand at two weeks after planting (2WAP) giving a population density of 222,222.22 plants/ha. Weeding was done twice with hoes on the plots that needed weeding at three and seven weeks after planting (3&7 WAP), while the no weeding plot was left without weeding throughout duration of celosia plants growth.

Parameters determined

Weed

Weed density: This was determined by using two quadrats of 50cm x 50cm and placing them randomly in each plot. This was done weekly starting from 4WAP.

Weed fresh and dry weight

Weed fresh and dry weight were determined by the same quadrat sampling techniques as used in weed density. This was

carried out once after the final harvest. Only part of the weeds above the soil surface were harvested and weighed. The weeds were carefully washed to remove any contamination by dipping them in a cylinder containing distilled water and later air-dried briefly. The fresh weight of the shoots was immediately taken with Hana weighing balance. The weed plant parts were then oven dried at 110^{o}c for 24hrs in envelops and weighed.

Weed control efficiency (WCE)

Weed control efficiency (WCE) of different treatments were calculated by Subramanian et al. (1991) as follow;

$$WCE\% = \frac{WDWC - WDWT}{WDWT} \; x\; 100 \qquad \text{……...…… (3)}$$

Where WDWC = weed dry weight of unweeded control
WDWT = weed dry weight in treated plots.

Celosia

Celosia parameters were collected by randomly selection and tagging of six plants from each treatment plot from net plot, they were tagged by placing labeled pegs beside them to facilitate the identification.

Number of leaves per plant

This was determined by counting at weekly interval starting from 4WAP.

Stem girth

This was measured by using non elastic thread tired around the circumference of the stem and spreading it out on a meter rule. This was also done at weekly interval starting from 4WAP.

Leaf area

This was determined by using the formula according to Pearcy *et al*., (1989). LA=0.5 (length x breadth of leaf).

Shoot height

This was determined by measuring the distance between the base of the shoot at the soil level to upper part of the terminal bud of the plant with a meter rule starting from 4WAP.

Cumulative fresh shoot marketable yield

Harvesting started from eight weeks after planting (8WAP), by cutting with knife from the 6 tagged plants used for sampling. The cutting was carried out at 15cmabove the soil surface. The second cutting of the shoot (offshoot) was at 10WAP. The 6 plants were weighed and their averages were taken per plant. The cumulative fresh shoot weight of the two harvests per plantwas determined by the summation of the first (1st) and second (2nd) harvests at 8WAP and 10WAP respectively. The fresh shoot marketable yield per hectare was calculated by multiplying the fresh shoot yield per plant by the plant population per hectare (222,222.22 plants/ha).Relative yield loss due to weeds was calculated based on the maximum yield obtained from a treatment according to the below formula adapted from Amare *et al*.(2014)

Relative yield loss %=

$$\frac{maximum\ yield\ from\ a\ treatment\ -\ yield\ from\ a\ a\ particular\ treatment}{maximum\ yield\ from\ a\ treatment}\ x\ 100.$$

…….…… (2)

Economics analysis

Economic evaluation of the different weed control methods was carried out using partial farm budgeting (Okoruwa *et al*., 2005). The cost of the input and price of the vegetable were obtained from the market survey. Sales revenue was obtained by multiplying the succulent shoot fresh weight (kg/ha) by the market price. Profit was obtained by subtracting the total cost of production from the sale revenue while Cost Benefit Ratio was done by Kay (1981) as follows:

$$CBR = \frac{cost\ of\ production}{profitt} \qquad \text{……..…. (3)}$$

Statistical analysis

Data generated were subjected to statistical analysis of variance (ANOVA) and significant treatment means were compared using least significant difference (LSD) at 5% probability level.

RESULTS

Chemical analysis of the dead mulch materials

The chemical composition of the four dead much materials before planting are presented in Table 1.The organic carbon (OC) ranged from 356 to398g/kg; Organic matter (OM) ranged from 61.37 to 68.62g/kg; Total N ranged from 1.00 to 20.00g/kg;C/N ratio ranged from 19.90 to 358.00; P ranged from 0.99 to 2.07mg/kg and K ranged from 0.11 to 2.98 cmol/kg

Soil Physico-chemical Properties

The effect of weed control treatment on soil properties before and after planting of Celosia argentea are presented in Table 2. Before planting, the soil was sandy loam with P^{H} of 5.6, nitrogen (N) phosphorus (P) and potassium (K) content of the soil were adequate. The organic matter of the soil was also adequate. After Celosia harvest the values of some of the physicochemical properties were altered. There was general increase in soil P^{H}, nitrogen content in all other soil properties slight increase and decrease were observed. The values of all the soil properties differ significantly ($p<0.05$) after harvest among the treatment except potassium (K). Sand particle ranged 600g/kg to 667g/kg; silt 52g/kg to185g/kg, clay, 200g/kg to 281g/kg, P^{H}, 5.7 to 6.5, N, 0.7g/kg to 4.6g/kg, P, 15.00mg/kg to 17.67mg/kg, organic matter, 26.90 to 56.48g/kg.

Weed growth characteristics

Weed density: The effect of mulching on weed density in *Celosia argentea* plot is presented in Table 3.All the weeds control treatments significantly ($p<0.05$) had effect on weed

density throughout the five (5) periods of sampling (Table3). At 8WAP, calopo mulch produced the lowest weed density of 15.5no/m^2whileunweeded (control) plot had the highest (63.0no/m^2).

Weed fresh Weight, Weed dry Weight and Weed control efficiency (WCE)

The effect of mulching on weed fresh weight, weed dry weight and weed control efficiency (W.C.E) in *Celosia argentea* plot is presented in Table 4. There was significant difference ($p<0.05$) among the treatments on weed fresh weight and dry weight. The highest weed fresh and dry weights of 3,505.13g/m^2 and 200.75g/m^2 respectively were recorded in weedy check and the lowest16.23g /m^2 and 0.50g/m^2 were recorded under calopo mulch plot. There was also significant difference ($P<0.05$) among the treatment in weed control efficiency. All the weed control treatments gave an efficient and acceptable ≥ 70% weed control. The WCE ranged from 93.31 to 99.76% with the hoe weeded plot at 3and 7weeks having the highest WCE while the lowest from guinea grass mulch.

was obtained in weedy check. Similar trends were observed at stem girth (Table6)

Number of Leaves and Leaf area

The effects of the mulchingon number of leaves and leaf area in *Celosia argentea* plot are presented in Tables 7 and 8. There was significant difference ($p<0.05$) on leaf production throughout the observation periods. Calopo mulch plots produced the highest number of leaves (64.25) while the unweeded had the lowest number (34.25) at 8WAP.Leaf area followed similar pattern as number of leaves (Table 8).

Marketable fresh shoot yield and relative yield loss

Table 9 shows effect of mulching on the marketable fresh shoot yield and relative yield loss in a *Celosia argentea* plot. The fresh shoot yield per hectare ranged from 16,444.44kg/ha to 42,5111.11 kg/ha. There were significant ($p<0.05$) differences among the treatments;. calopo mulch produced the highest fresh shoot yield(42,5111.11kg/ha) while the lowest came from the unweeded (control) (16,444.44kg/ha).

Table1. Chemical composition of the four dead mulch material before planting

Mulch type	OC (g/kg)	OM (g/kg)	Total N (g/kg)	C/N ratio	P (mg/kg)	K (cmol/kg)
Calopo mulch	398.00	68.62	20.00	19.90	1.00	0.11
Guinea grass mulch	361.00	62.23	11.40	31.67	0.99	0.15
Saw dust mulch	356.00	61.37	1.10	323.63	2.05	2.95
Wood shavings mulch	358.00	61.72	1.00	358.00	2.07	2.98

Table 2.Effect of mulching on some physico-chemical properties of soil before and after planting in a *Celosia argentea* plot

Treatment	Sand kg^{-1}	Silt gkg^{-1}	Clay kg^{-1}	P^H	N gkg^{-1}	P $mgkg^{-1}$	K $cmolkg^{1}$	OM gkg^{-1}
Initial value(before cropping)	662.00	278.00	60.00	5.60	1.51	15.67	0.24	28.24
Final value (after harvest/cropping)								
Calopo mulch	600.00	185.00	215.00	6.50	4.60	17.67	0.48	56.48
Guinea grass mulch	615.00	140.00	245.00	6.30	3.50	16.58	0.30	40.14
Sawdust mulch	650.00	150.00	200.00	6.10	2.40	15.69	0.28	37.00
Wood shavings mulch	645.00	95.00	260.00	6.00	2.30	15.70	0.27	36.18
Two-Hoe weeding @3&7WAP(control)	665.00	55.00	280.00	5.70	0.90	15.21	0.21	28.00
Unweeded (control)	667.00	52.00	281.00	5.80	0.70	15.00	0.20	26.90
LSD (P=0.05)	NS	5.94	28.24	1.07	0.15	0.36	NS	1.75

Table 3. Effect of mulching on weed density (no/m^2) in a *Celosia argentea* plot

Treatment	Weeks after planting(WAP)				
	4	5	6	7	8
Calopo mulch	1.25	5.00	6.50	10.75	15.50
Guinea grass mulch	2.00	7.00	8.75	13.25	23.50
Sawdust mulch	3.50	10.75	15.50	21.75	31.25
Wood shavings	3.25	13.25	13.75	19.75	25.50
Two-hoe weeding @3&7WAP (control)	2.00	4.75	6.75	10.00	2.25
Unweeded (control)	18.50	28.25	37.00	48.75	63.00
LSD(P=0.05)	1.34	1.60	2.66	3.24	2.71

Vegetative traits

Shoot heights and stem girth: The effects of the mulching on shoot height and stem girth in *Celosiaargentea* plot are presented in Tables 5 and 6 respectively. There was significant difference ($p<0.05$) among the treatments throughout the observation periods (4, 5, 6, 7 and 8WAP) on shoot height. There was steady increase in plant height throughout the five (5) periods of sampling. At 8WAP, the tallest plant (93.33cm) was obtained on calopo mulch while the shortest (42.78cm)

Relative to the unweeded (control) mulching increased celosia fresh shoot marketable yield by 2,485.14% (calopo mulch), 121.62% (Two –hoe weeding @ 3 & 7WAP), 70.27%, (guinea grass mulch)50% (wood shaving mulch) and 25.68 % (saw dust mulch)compared with the no weeding check. The relative yield loss ranged from 91.42% to 96.14% with the unweeded control plots having the highest yield loss while the plots hoe weeded twice at 3and 7WAP had the lowest when compared with the appropriate maximum yield (425,111.11kg/ha) obtained under calopo mulch. A yield reduction of 54.88%

was obtained with unweeded situation compared to plot manually hand weeded twice.

Economic Evaluation

Economic analysis of the mulching methods in a *Celosia argentea* plot are presented in Table 10. The Table showed that the yield per hectare of *C. argentea* ranged from 16,380kg/ha to 425,111.11kg/ha with calopo mulch recording the highest fresh shoot yield while the unweeded (control) the lowest. The cost of production ranged from₦0 to₦108,000with plot hoe weeded twice having highest cost of production₦108,000.00 and the lowest(₦0) from the unweeded plot. The profitability was in order of calopo mulch (₦85007222) >Two-hoe weeding@3 &7 WAP (₦7180888)> guinea grass (₦5583500)>wood shavings (₦4915834)> sawdust mulch (₦4115834)> unweeded (₦328888). The highest cost benefit ratio (CBR) was recorded under calopo mulch(1:5667.15) followed by guinea grass mulch (1:338.39),wood shavings(1:280.90), saw dust (1: 235.19) and Two-hoe weeding @3 &7 WAP (1:66.49)

DISCUSSION

The observed high C/ Nratio for wood shavings and saw dust mulch implied thatthe materials had a slower rate of decompositionwhile the low C/N ratio of calpo and guinea grass mulchsimplied a faster rate of decomposition. Rynk (1992) reported that high lignin materials such as sawdust decomposed slowly due to their high C/N ratioof 300-700.The initial P^H of the soil was slightly and fell between the pH values required for arable crops production in Nigeria. This assertion is in agreement with that of Enwezor *et al.,* (1990) who noted that the optimum soil pH range for producing arable crops in Nigeria is between 5 and 7.The organic carbon, nitrogen, phosphorus and potassium content of the soil before celosia planting were quite adequate when compared to their various critical level in the soil outlined by Ibedu *et al.* (1988). Due to their adequacies there were no need to add manure or fertilizer as an input. No weeding plots gave the highest weed density and dry weight owing to their greater competitive ability with celosia plants.

Table 4.Effect of mulching on weed fresh and dry weight and weed control efficiency in a *Celosiaargentea* plot at final harvest

Treatment	Weed fresh weight (g/m^2)	Weed dry weight (g/m^2)	Weed control efficiency(%)
Calopo mulch	195.55	13.05	93.50
Guinea grass mulch	236.50	13.43	93.31
Sawdust mulch	174.30	9.10	95.47
Wood shavings	160.40	8.88	95.58
Two-hoe weeding 3&7WAP (control)	16.23	0.50	99.76
Unweeded (control)	3,505.13	200.75	–
LSD(P=0.05)	54.02	4.03	0.57

Table 5. Effect of mulching on shoot height (cm) in a *Celosia argentea* plot

Treatment	Weeks after planting				
	4	5	6	7	8
Calopo mulch	17.83	29.48	44.23	67.68	93.33
Guinea grass mulch	13.75	24.00	36.50	52.00	67.33
Sawdust mulch	12.75	22.25	30.25	46.50	60.38
Wood shavings	12.25	20.95	32.20	48.75	63.63
Two-hoe weeding 3&7WAP (control)	17.20	27.40	40.25	61.25	84.85
Unweeded (control)	7.98	15.90	25.63	33.88	42.78
LSD(P=0.05)	1.62	2.71	2.00	2.73	3.05

Table 6. Effect of mulching on the stem girth (cm) in a Celosia argentea plot

Treatment	Weeks after planting				
	4	5	6	7	8
Calopo mulch	0.48	0.97	1.70	2.18	3.25
Guinea grass mulch	0.46	0.65	1.18	1.53	1.79
Sawdust mulch	0.45	0.60	0.70	1.20	1.95
Wood shavings mulch	0.43	0.77	0.88	1.43	2.05
Two-hoe weeding 3&7WAP (control)	0.44	0.95	1.53	1.95	3.09
Unweeded (control)	0.22	0.41	0.51	0.78	1.45
LSD(P=0.05)	0.04	0.077	0.15	0.21	0.051

Table 7.Effect of mulching on number of leaves in a *Celosia argentea* plot

Treatment	Weeks after planting				
	4	5	6	7	8
Calopo mulch	10.95	19.55	34.30	46.75	64.25
Guinea grass mulch	9.88	15.50	25.50	35.30	54.50
Sawdust mulch	9.75	16.75	19.75	31.75	42.50
Wood shavings mulch	9.75	15.25	23.00	30.75	46.50
Two-hoe weeding 3&7WAP (control)	10.00	18.00	32.50	44.25	60.75
Unweeded (control)	5.50	9.75	15.25	22.00	34.25
LSD(P=0.05)	2.62	1.53	1.51	1.92	1.65

Table 8. Effect of mulching on leaf area (cm^2) in a *Celosia argentea* plot

Treatment	Weeks after planting				
	4	5	6	7	8
Calopo mulch	26.50	37.68	48.55	62.70	79.78
Guinea grass mulch	25.93	32.60	36.10	46.68	67.40
Sawdust mulch	24.78	29.68	32.88	38.00	52.03
Wood shavings mulch	24.63	28.25	33.00	43.25	63.13
Two-hoe weeding 3&7WAP (control)	26.13	36.55	44.25	54.75	72.83
Unweeded (control)	13.20	16.85	22.13	27.63	36.88
LSD(P=0.05)	1.09	1.90	1.09	6.58	1.92

Table 9.Effect of mulching on the marketable fresh shoot yield and relative yield loss in a *Celosia argentea* plot

Treatment	Fresh shoot weight (kg/plant)	Yield (kg/ha)	Relative yield loss (%)
Calopo mulch	1.913	425,111.11	–
Guinea grass mulch	0.126	28,000.00	93.41
Sawdust mulch	0.093	20,666.67	95.14
Wood shavings mulch	0. 111	24,666.67	94.20
Two-hoe weeding 3&7WAP (control)	0.164	36,444.44	91.43
Unweeded (control)		16,444.44	96.13
LSD(P=0.05)	035	7,777.780	0.807

Table 10. Economic analysis of the mulching methods in a *Celosia argentea*plot

Economic parameters	Calopo mulch	Guinea grass mulch	Saw dust mulch	Wood shavings mulch	Two-hoe weeding @ 3&7WAP (control)	Unweeded (control)
Celosia fresh shoot yield (kg/ha)	425,111.11	28,000	20,666.67	24,666.67	36,444.44	16,444.44
Sale revenue(₦/ha)	85022222	5600000	4133334	4933334	7288888	3288888
Production cost (₦)						
Cutting, drying and transportation of	30man-hr/ha @ ₦300/hr ₦9000*	30man-hr/ha @₦350/hr ₦10,500**				
Packing and transportation			25man-hr/ha @ ₦300/hr ₦7500***	25man-hr/ha @ ₦300/hr ₦7500***		
Application Weeding	20man-hr/ha @ ₦300/hr ₦6000****	20man-hr/ha @₦ 300/hr ₦6000****	25man-hr/ha @ 400/hr ₦10000*****	25man-hr/ha @ ₦400/hr ₦10000******	240man-hr/ha @₦450/hr ₦108,000******	
Total cost of Production	₦15000	₦16500	₦17500	₦17500	₦108,000	0
Profit	₦85007222	₦5583500	₦4115834	₦4915834	₦7180888	₦328888
Cost Benefit Ratio (CBR)	1:5667.15	1:338.39	1: 235.19	1:280.90	1:66.49	∞

1kg of fresh shoot celosia vegetable =₦200,1 US$as the time of harvesting for sale between June and July2012=₦163.32

*Cost of cutting, drying and transportation of calapo mulch=₦300/hr(₦1,400–₦1,600) = (₦1,500 average) between 7.0a.m – 12noon = 5hrs approximately.

**Cost of Cutting, drying and transportation of guinea grass mulch=₦350/hr(₦1,500–₦2,000) = (₦ 1,750average) between 7.0a.m – 12noon = 5hrs approximately.

***Cost of packing and transportation of wood shavings and saw dust mulch, each =₦300/hr(₦1,400–₦1,600) = (₦1500 average) between 7.0a.m – 12noon = 5hrs approximately.

****Cost of application of calopo mulch and guinea grass mulch, each =₦300/hr(₦1,400 –₦1,600) = (₦1500 average) between 7.0a.m – 12noon = 5hrs approximately.

*****Cost of application of wood shavings mulch and saw dust mulch each =₦400/hr(₦1,8 00–₦2200) = (2000 average) between 7.0a.m – 12noon = 5hrs approximately.

******Cost of hoe weeding ₦450/hr (₦2000 – ₦2,500) = (₦2250 average) between 7.0a.m=5hrs.approximately.

The increase could be attributed to unprotected nature of plots by any covering material thereby exposing the soil to light intensity which promotes maximum photosynthesis. The best weed suppression and higher efficiency observed in plots hoe weeded twice at 3 and 7 WAP judging from their higher weed control efficiencies may be attributed to their first and second weeding which resulted in the low weed density and dry weight. Weeds that have escaped control during the first weeding might have been controlled at the second weeding. Wood shavings and saw dust mulches were better than calopo and grass mulches in weed control efficiency probably due to better soil coverage and slower rate of decomposition as result of their high carbon/nitrogen ratio (C:N) of 358 and 323.63 respectively. Rynk (1992) suggested that perennial weeds could be controlled by organic materials that had C/N ratio that ranged from 300 – 700. Based on this study calopo and guinea grass mulch with low C/N ratio could be suitable for arable crops that had a shorter duration whose weeds are mostly annuals. Generally, the mechanism of dead mulch materials in weed smothering could be attributed to their ability to hindered sun light penetration into the soil or to cut off light from penetrating into the soil hence few weeds were recorded in them when compared with no weeding plots. Ozores-Hampton *et al.* (2001) noted that weed suppression by dead mulch (organic mulch) is due to the physical presence of the materials on the soil surface and/or the action of phytotoxic compounds generated by microbes. Okhiria *et al.* (1992), also noted high smothering effect of dry mulches on weed growth in Celosia plots. In the same vein, Lal1977 and Bhattacharya *et al.* (1985) noted effective weed suppression bysoil covers in cultivated fields. The best growth and yield performance recorded under calopo mulch in terms of shoot height, stem girth, number of leaves, leaf area and shoot weight might be attributed to better conservation of moisture of the mulch material for celosia plant growth. Influence of water conservation of different mulch types in crops had been

documented by several researchers (Opara-Nadi, and Lal, 1987; Salau *et al*., 1992). Another reason for the remarkable growth performance of celosia plants grown with calapo mulch could be attributed to the potentiality of calapo mulch to add more nutrients to the soil judging from the high value of nutrient elements obtained during final soil analysis. It is interesting to note that the calapo mulch had a low C/N ratio of 19.90. The low C/N ratio of the materials might had facilitated the faster decomposition and more released of nutrients into the soil. Plots that were manually hoe weeded twice was next to calopo mulch in terms of plant growth performance but their weed control efficiencies were better than that calopo mulch plots. The high efficiencies might have contributed to their better growth and yield performances as against guinea grass mulch. However, the mulching effect of the guinea grass mulch coupled with the release of nutrients into the soil as result of low C/N ratio when compared with wood shavings and sawdust maybe responsible for its good growth and yield performances. Although, wood shavings and sawdust mulches had the best weed control efficiencies when compared to the rest treatments but their plant growth and yield performances were not quite encouraging. Two probable reasons might be adduced to it. The first reason could be that the two mulch materials were able to produce some toxins substances which might have interferes with the celosia plant growth and the second reason might be attributable to immobilization of soil nitrogen by the soil microbes due to high C:N ratio present in both materials. Immobilization of soil nitrogen in wood shaving and saw dust mulch materials had also been reported by Owaiye (1993)

The poor growth performance recoded in the unweeded (control) plots might be attributed to serious weed competition between the celosia plants and weeds. Weeds compete with the celosia plants for below and above ground above resources such as light, water, nutrients, oxygen and carbon (iv) oxide which result in their yield loss. Mulch brought about a change in cost of production when compared with hoe weeding. Reduced cost of production of the four dead mulches used in the study could probably be a result of no cost of purchase. The high cost of production recorded in plot weeded twice could be as a result of high cost of labour, since there were scarcity of labours as at the time of weeding. The results obtained from net revenue (profit) were due to differences in yield per hectare recorded by the difference treatments. Wood shavings and sawdust mulch had same cost of production but differ in yield. Similarly, calopo and guinea grass mulch had the same cost of production but with yield variation although all the weed control treatments were economically viable and profitable but celosia plants grown with calapo mulch recorded the highest profit (₦85007222) and also high cost benefit ratio (1:5667.1). This further implied that for every one naira invested on celosia vegetable production, a profit of₦5667.15will be realized. The no weeding plot had no cost of production because there were no input added hence the cost benefit ratio was undefined.

Conclusion and Recommendation

The outstanding findings drawn from this study showed that: hoe weeding at 3 &7 WAP was significantly more efficient in controlling weeds followed by wood shavings mulch, sawdust mulch, calopo mulch and then guinea grass mulch. The best growth and yield performance were recorded under calopo mulch .The hand-weeded plots also had better yields but the cost of hoe weeding might make it less *enchanting* to celosia growers' when compared to dead mulch materials. Mulching altered some of the physicochemical characteristics of the soil through increase or decrease in values. All the weed control treatments were all economic viable and profitable but celosia plants grown with calapo mulch recorded the highest profit and cost benefit ratio hence it can be recommended to celosia growers' in the area of study.

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