EFFECT OF DIFFERENT MULCHING MATERIALS AND RATE OF APPLICATION ON GROWTH AND YIELD OF OKRA (Abelmoschus esculentus L.)

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ABSTRACT

Field trials were conducted at University Organic–Agriculture farm, Federal University of Agriculture Abeokuta in 2011 to determine the response of different mulching materials on growth and yield of okra. It was a 3x3 factorial laid out in Randomized Complete Block Design (RCBD) with the main factor as the plant material *Chromolaena odorata* (*CO*) *Glycine max* (GM) and *Panicum maximum* (PM) while rate (0, 5 and 10t/ha) of mulching materials were applied once before the first cropping was the sub-factor and all were replicated three times. Data were collected on growth parameters and yield attributes of okra (NHAE- 47-4) at first and second planting. The parameters assessed were significantly influenced ($P \leq 0.05$) by the mulching material and rate of application. Higher values for plant height (56.3cm and 60.7cm) , number of leaves (22 and 22) and stem girth (1.5cm and 2.1cm) at 16 weeks after planting (WAP) were obtained during the first and second planting from CO application of 10t/ha. Although, the higher number of flowers (14 and 21), number of pods (29 and 21) and weight of pods/plant (0.51kg and 0.44kg) were derived from PM when 10t/ha was used at 16 WAP during both plantings. Thus, optimum okra yield were obtained with application of 10t/ha of plant residues, therefore, mulching with PM residues at 10t/ha is recommended for high fruit yield of okra in the region of investigation.

Key words: Okra, mulching materials, rate of application, growth and yield.

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INTRODUCTION

The return of plant residues to soil after harvest and as mulching materials constitute an important management practice that enhance nutrient recycling and biological activities on most farms. Crop residue management has also been suggested as an alternative (Moldenhaver e*t al*., 1991; Sandretto and Bull, 1996; CTIC, 2000) to effective soil management. Organic mulch can enhance crop growth and competitiveness against weeds by conserving soil moisture and moderating soil temperature (Schonbeck, 2007). Soil micro-organisms are the main actors in residue decomposition and nutrient release. Thus, soil biota increase in a mulched soil environment thereby improving nutrient cycling and organic matter build up over a period of several years (Holland, 2004).

However, not all organic materials are suitable for mulching. Sometimes the physical properties of an organic material that make it good for compost may also make it unsuitable as a mulching material (Pullman *et al*., 2005). Materials like cotton gin waste, rich hulls, peanut hulls and buck wheat hulls- may be available in quantity in certain locales. Their ability to suppress weeds may vary, depending on texture and possibly chemical properties (Brown, *et al*., 1996).

Improve level of soil fertility has been observed using the rate of decomposition of mulch materials. Infect the effects of quality of chemical properties of different mulch materials have not been quantified on soil chemical properties, especially decomposition and nutrient release of the mulching materials. Similarly, residue decomposition and nutrient release have been related to quality of plant materials, the effects of the residue quality have not been largely related to nutrient uptake by crops. Decomposing plant residues are reported to release substantial levels of nutrients and organic matter into the soil (Yih-chi *et al*., 2009).

Nutrient release from decomposing plant materials may be substantial enough to sustain optimum yield of Okra. Mulching material generally support fauna activities which in turn enhance the release of nutrient from plant materials. Also, the availability of high quantity mulching plant materials may pose constrain to the use of mulching practise in enhancing nutrient supply for okra production. The optimal nutrient management strategy is to synchronize the release of nutrients with patterns of plant uptake and consequently minimize wastefulness and or non-synchronized nutrient release for optimum okra production.

Information is presently insufficient on the alternative use of different plant materials sources such as legumes and grasses as mulching on the production of okra in Abeokuta, Ogun state. Therefore, this study was conducted to determine the effect of different mulching materials and the rate of appropriate application on growth and yield of okra in Abeokuta agro-ecological zone.

Materials and Methods

The experiment was carried out at University Organic Agriculture Farm of the University of Agriculture, Abeokuta, Ogun State Nigeria (7^0 13'N, $3^0$28'E) in 2011. The site is with altitude 108m and mean annual rainfall of 1,200 mm. The field trials were carried out twice, first planting fell between May and August while the second cultivation was done between September and December. The fields were cleared, ploughed twice and harrowed. Soil samples were taken randomly from the location of the field using auger (0 – 15 cm depth), were bulked together and later air –dried for 48 hours and then sieved using a 2 mm sieve to remove gravel for the laboratory routine (sub samples were further pulverized and sieved using 0.5 mm sieve for organic and total N) and characterized for the following; pH in water using pH meter potentiometrically, Organic carbon content using the Walkey- black procedure (Amato), Particle size using the hydrometer method (Bouyoucos, 1962) and the proportion of sand, clay and silt used to determined the textural class using the USDA textural triangle, Available P was determined using wet digestion by mixing $HClO_4$-HNO_3(1:4) and use of auto-analyser by the molybdate blue method to measure P colourimetrically (Okalebo *et al*.,1993), Total Nitrogen was determined using Micro Kjeldahl , K was determined by flame photometry and Exchangeable Ca and Mg were determined by atomic absorption spectrophotometer. Similarly the nutrients content of the mulching materials were also analysed to reveal the nutrients content.

The experiment was set up as a 3x3 factorial laid out in Randomized Complete Block Design (RCBD) with the main factor as the plant material *Chromolaena odorata* (CO), *Glycine max* (GM) and *Panicum maximum* (PM) while rate (0, 5 and 10t/ha) of mulching materials were applied once before the first cropping was the sub-factor and all were replicated three times. The plant materials used as residue and mulching materials were sourced from the University Organic Agriculture farm. The test crop was okra (NHAE 47- 4) chosen for its viability and sourced from National Institute of Horticultural Research.

The plot size used was 1m by 2m ($2m^2$) and planting was carried out after tillage operation. Each experimental plot was sown with three seeds of okra at a spacing of 30cm and at depth of about 3cm. Thereafter, mulching with above specified rates was carried out on each plot two weeks after planting. Watering and weeding were done manually twice before harvesting.

Data collected from decomposed plant residues, soil and agronomic parameters of okra plant such as number of leaf, plant height, leaf area, stem girth, number of pod, number of fruit and weight of fruit from seedlings to near terminal stages. All data collected from the experiments were subjected to analysis of variance using Gensat Discovery Version. Treatment means were separated using the least significant difference (LSD) methods.

Result and Discussion

The properties of the soil used for the study were shown in Table 1. It revealed that the soil had slightly acidic reaction; the textural class of soil was loamy sand; organic matter (0.40%), organic matter (0.68%), total N (0.83%), Zn (12.6mgkg^{-1}) and Mn (14.97mgkg^{-1}). The soil was Temidire series, which has been classified as an Alfisol. The low fertility status of the soil has been known to be due to continuous cropping indicating that the nutrients reserve capacity of the soil was minimal. Thus, the incorporation of crop residues is essential for sustaining soil productivity through replenishing soil organic matter(SOM) has suggested by (Kumar and Goh, 2000).

The property of plant residues used in this experiment is shown in Table 2. Nitrogen, Phosphorus, Calcium and Magnesium were higher in *C. Odorata* compared to other plant residues. *Glyxine max* followed in nutrient value to *C. odorata* in N,P, Ca and Mg while K was higher in *P. maximum* than other residues. The N,P,Ca and Mg contents indicated that *C. Odorata* had a better quality than either of the two residues considering the magnitude of the essential nutrients in these residues. It can be deduced that each crop residue has a potential with variation between them as a source of soil amendment (Adekunle *et al*., 2013).

Effects of plant materials mulching on number of leaves of Okra during first and second planting periods

Tables 3 and 4 showed that more leaves of okra were produced during second planting than first planting in all treatments examined. From all the treatments (Siam weed) Produced more leaves than *G. max (soybean)* and *P. maximum* (Gg (Guinea grass) from 8 to 16 Week after Planting (WAP) during both planting periods.

Similarly, Tables 5 and 6 showed the effect of interactions between the plant materials ©. *Odorata, G. max and P. maximum*) and the rates (0, 5 and 10t/ha) of application. The results showed that all interactions were highly significant from 0 to 16 for the production of okra leaves. More leaves were produced from all treatments used during the second planting than first planting. It was seen that the highest number of leaves were produced from *C. Odorata* (*Siam* weed) with 10t/ha followed by *G. max* 10t/ha while the least number of okra leaves was given by Soybean with 0t/ha during first and second planting. *C. odorata* and G. max produced higher number of leaves with 10t/ha. More nutrients were released for production of leaves with 10t/ha of *Siam* weed than other rates (0 and 5t/ha).

Effects of plant materials mulching on height of okra stems during first and second planting periods

Result from Tables 7 and 8 showed that mulching materials were statistically different from one another from 6 to 8 WAP during both plantings. From the result *C. odorata* had higher height than *G. max* and *P. maximum* at 16 WAP during both plantings.

Tables 9 and 10 showed the effect of interaction of all treatments to be significant from 10 to 16 WAP for stem height of okra. All treatments showed that higher heights of okra stems were produced during second planting than the first. It was observed that okra plants of higher heights were produced from all treatments of 10t/ha in all mulching plant materials than other treatments.

Effects of plant materials mulching on stem girth of Okra plant during first and second planting periods

The response of all the growth parameter considered to the applied treatments inferred that use of crop residues as mulch was effective sources of nutrient to Okra plant. The observed findings corroborated with the work of (Schonbeck, (2007) who reported that organic mulch can enhance crop growth and competiveness against weeds by conserving soil moisture and moderating soil temperature. Similarly, the performance of the mulch treated plots compared to the control affirms the findings of (Mohler and Di Tommaso, (2008) that organic mulches suppress weeds in several ways; they block seed germination stimuli by intercepting light, reducing soil temperature fluctuations. The performance of the mulching material agrees with the reports of (Mbah and Mbagwu, (2003) who ascertained that organic wastes differ in their ability to provide nutrients and

enhance soil qualities due to difference in their rate of decomposition and nutrient release patterns. The higher performance shown by *C. Odorata* in all the vegetative characters examined was in accordance with the findings of (Ojeniyi and Ighomere,-(2004). They found that mulching with *C. odorata* and leguminous plant increased soil formation plant nutrients and tuber yield of cassava significantly due to release of nutrients from its residue.

Effects of mulching with plant materials on yield of Okra.

Result from Table 13 showed that all the mulching plant material treatments used for the study were highly significant from 10 to 16 WAP during both planting periods. Flowering occurred at 10th week after planting (WAP) and Okra plants mulched with *P. maximum* residue were seen to flower first before other plant residues (*G. max* and *C. odorata*). It was observed that more flowers were produced during second planting in all treatments considered. Although, *C. odorata* with 10t/ha gave higher number of flowers, followed by *G. max* with the least. However, the least was observed from *G. max* treated plot.

Table 14 result showed that the interaction of all treatments used for mulching plant materials studied were highly significant from 12 to 16 WAP during second planting period. It was observed that higher number of pods was formed during second planting than first planting. More so, higher numbers of pods were observed in *G. max* with 10 and 5 t/ha than other treatments. This was followed by *P. maximum* with 10 t/ha treated plot. *C. odorata* gave the least significant number of pods production despite the higher significant flower production at 16WAP for both planting periods.

Table 15 also, showed that the interaction for all the treatments used for the study were highly significant at 5% during both plantings. It was observed that higher weight of pods of Okra fruits were produced during first than second planting period. *P. maximum* with 10 t/ha gave the higher weight of pods.

All the characters examined increase with type of mulching material and the quantity added. The better performance of growth and yield parameter in second planting period over the first and significance of interaction in both plantings affirms the work of (Abouel- Magd *et al*., (2005) that nutrients contained in organic manures are released more slowly and stored for a longer time in soil. The better performance of 10 t/ha over 5t/ha and 0t/ha, ascertain (Sharma and Mitra, -(1991) work that large amount of manure support slow longer period of storage in the soil there by ensuring a long residual effects. The higher number pods produced by *G. max* mulching material thus, confirmed the findings of (Nottidge *et al*.,-(2010) that the incorporation of residues of leguminous food crops such as groundnut and cowpea are good alternatives in improvement of soil physical conditions and productivity of maize than on short or bare fallow lands. The highest performance shown by *P. maximum* in both planting periods on the yield and yield components examined supported the findings of (Brown *et al*.,(1996) that because of its high carbon – to-nitrogen (C: N) ratio, grass hay has sometimes been reported to tie up soil N.

Table 1:Pre-physico-chemical properties of the soil used

Soil properties	Units	Values
pH		6.35
Organic matter	%	0.68
Total Nitrogen	%	0.034
Available Phosphorus	mg kg^{-1}	16.9
Exchangeable – K	$cmolkg^{-1}$	0.35
Exchangeable – Ca	$cmolkg^{-1}$	0.86
Exchangeable – Mg	$cmolkg^{-1}$	2.17
Exchangeable – Na	$cmolkg^{-1}$	0.49
$H^+ + Al^{3+}$	$mgkg^{-1}$	3.87
ECEC		
Cu	$mgkg^{-1}$	1.63
Zn	$mgkg^{-1}$	12.6
Fe	mg kg^{-1}	10.6
Mn	mg kg^{-1}	14.97
Particle size		
Sand	g kg^{-1}	856
Clay	gkg^{-1}	66
Silt	gkg^{-1}	76
Textural class		Loamy sand
Soil series		OxicTropudalfs,

Table 2: Nutrient composition of plant residues used as mulching materials

Plant residue	N	P $Mgkg^{-1}$	K	Ca	Mg
Chromolaenaodorata	36.0	21.0	16.5	39.5	10.2
Panicum maximum	33.2	9.8	19.5	5.5	3.0
Glycine max	35.0	14.0	3.9	18.6	8.2

Table 3: Effect of mulching with plant materials on number of leaves of okra plant during first planting

Treatments	2	4	6	8 WAP	10	12	14	16
Chromolaenaodorata	3.00a	6.22a	10.1a	12.9a	13.8a	15.4a	17.1a	16.1a
Glycine max	3.00a	6.00b	8.33b	11.0b	12.3b	14.0b	15.3b	13.2b
Panicum maximum	3.00a	6.00b	8.00c	10.0c	10.8c	12.0c	12.9c	10.9c

Means followed by the same letter in the same columns are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT)

Table 4: Effects of mulching with plant materials on number of leaves in okra plant during second planting

Treatments	2	4	6	8 WAP	10	12	14	16
Chromolaenaodorata	4.00a	7.0a	8.7a	18.4a	19.3a	21.6a	23.94a	22.54a
Glycine max	4.0a	6.9a	8.3c	15.5b	17.2ab	19.6a	21.42a	18.48a
Panicum maximum	4.0a	7.0a	8.6b	14.0c	15.1b	16.8ab	18.06b	15.26a

Means followed by the same letter in the same columns are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT)

Table 5: Effect of mulching plant materials and rates interactions on number of leaves of okra during the first planting

		2	4	6	8	10	12	14	16
	---			WAP					-----
ate	Residue								
t/ha	Control	3	6	8	10	10	12	13	11
t/ha	*Chromolaena*	3	6	9	12	13	14	16	16
	Glycine	3	6	8	11	13	14	16	13
	Panicum	3	6	8	10	12	13	13	11
0 t/ha	*Chromolaena*	3	7	13.3	17	18	20	22	21
	Glycine	3	6	9	12	14.7	16.7	18	16
	Panicum	3	6	8.04	10	10.9	11.9	12	10
SD(R)		Ns	Ns	x	x	x	x	x	X
SD (T)		Ns	Ns	x	x	x	x	x	X
SD (RxT)		Ns	Ns	x	x	x	x	x	x

NS = not significant x = P≤ 0.05, WAP= Weeks After Planting

Table 6: Effect of mulching plant materials and rates interactions on number of leaves of okra during the second planting

		2	4	6	8	10	12	14	16
	---			WAP					-----
	Residue								
a	Control	4	7	8	9	14	16	18	15
ıa	*Chromolaena*	4	7	8	10	18	20	22	22
	Glycine	4	7	8	10	18	20	22	19
	Panicum	4	7	8	9	16	18	19	16
ha	*Chromolaena*	4	7	10	12	25	28	31	30
	Glycine	4	7	8	11	21	23	26	23
	Panicum	4	7	10	11	15	17	17	15
(R)		Ns	Ns	x	Ns	x	x	x	Ns
(T)		Ns	Ns	x	Ns	x	x	x	Ns
(RxT)		Ns	Ns	x	Ns	x	x	x	X

NS = not significant x = P≤ 0.05, WAP= Weeks After Planting

Table 7: Effects of mulching with plant materials on plant height (cm) of okra plant during first planting

Treatments	2	4	6	8 WAP	10	12	14	16
Chromolaenaodorata	4.18a	7.03a	23.00a	31.90a	39.60a	44.00a	47.90a	49.00a
Glycine max	3.80a	6.78a	19.90b	30.40b	37.10b	41.50b	46.10b	47.20b
Panicum maximum	4.06a	6.19a	18.00c	28.00c	35.00c	39.30c	43.00c	43.90c

Means followed by the same letter in the same columns are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT)

Table 8: Effects of mulching with plant materials on plant height (cm) of okra plant during second planting

Treatments	2	4	6	8 WAP	10	12	14	16
Chromolaenaodorata	5.50a	7.00a	21.20a	36.10a	55.40a	61.60a	67.06a	68.60a
Glycine max	5.40a	6.90a	19.90b	34.4a	51.9a	58.1a	64.54a	66.10a
Panicum maximum	5.30a	7.00a	18.00c	32.20b	49.00a	55.00a	60.20a	61.46a

Means followed by the same letter in the same columns are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT)

Table 9: Effect of mulching with plant materials on stem girth (cm) of okra plant during first planting

Treatments	2	4	6	8 WAP	10	12	14	16
Chromolaenaodorata	0.13[a]	0.25[a]	0.88[a]	1.11[a]	1.15[a]	1.27[a]	1.40[a]	1.40[a]
Glycine max	0.12a	0.23b	0.75b	1.02b	1.07b	1.20b	1.30b	1.30b
Panicum maximum	0.13a	0.22b	0.70c	0.95c	1.05c	1.17c	1.13c	1.13c

Means followed by the same letter in the same columns are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT)

Table 10: Effect of mulching with plant materials on stem girth (cm) of okra plant during second planting

Treatments	2	4	6	8 WAP	10	12	14	16
Chromolaenaodorata	0.16a	0.30a	0.77a	1.56a	1.61a	1.80a	1.96a	1.96a
Glycine max	0.16a	0.30a	0.77a	1.42b	1.50a	1.70a	1.82a	1.82a
Panicum maximum	0.14a	0.30a	0.74b	1.32c	1.47a	1.60a	1.82	1.82a

Means followed by the same letter in the same columns are not significantly different at 5% level of probability by Duncan's Multiple Range Test (DMRT)

Table 11: Effect of mulching plant materials and rates interactions on girth (cm) of okra plant during the first planting

		2	4	6	8	10	12	14	16
		---		WAP					-----
	Residue								
a	Control	0.12	0.22	0.67	0.89	1.01	1.15	1.24	1.27
ıa	*Chromolaena*	0.13	0.25	0.88	1.15	1.16	1.28	1.41	1.40
	Glycine	0.12	0.24	0.77	0.98	1.08	1.18	1.3	1.30
	Panicum	0.12	0.21	0.73	0.90	1.04	1.17	1.27	1.30
ha	*Chromolaena*	0.16	0.26	1.10	1.31	1.29	1.40	1.50	1.50
	Glycine	0.13	0.22	0.78	1.18	1.14	1.24	1.34	1.40
	Panicum	0.12	0.24	0.75	1.13	1.07	1.22	1.31	1.30
	Ns	ns	0.02	0.0001	0.001	0.0001	0.005	0.007	0.009

NS = not significant , WAP= Weeks After Planting

Table 12: Effect of mulching plant materials and rates interactions on stem girth (cm) of okra during the second planting

		2	4	6	8	10	12	14	16
		---		WAP					-----
	Residue								
a	Control	0.13	0.24	1.14	0.74	1.41	1.61	1.74	1.77
ıa	*Chromolaena*	0.16	0.46	0.81	0.94	1.62	1.79	1.97	1.96
	Glycine	0.17	0.28	0.78	0.89	1.51	1.65	1.82	1.82
	Panicum	0.14	0.26	0.77	0.69	1.46	1.64	1.78	1.82
ha	*Chromolaena*	0.19	0.31	0.87	0.99	1.81	1.96	2.10	2.10
	Glycine	0.18	0.30	0.83	0.98	1.60	1.74	1.88	1.96
	Panicum	0.16	0.29	0.80	0.94	1.50	1.71	1.83	1.82
(R)		NS	NS	NS	x	x	x	x	NS
(T)		NS	NS	NS	x	x	x	x	NS
(RxT)		NS	NS	NS	NS	x	x	x	

NS = not significant x = P≤ 0.05, WAP= Weeks After Planting

Table 13: Effects of mulching with plant materials and rate interaction on number of flowers of okra plant during both planting.

Rate	Residue	10	12	14	16	10	12	14	16
0 t/ha	Control	3	3	3	3	4	5	5	5
5t/ha	*Chromolaena*	3.54	4.00	4.20	3.63	4.95	6.37	5.90	5.90
	Glycine	4.18	4.79	5.06	4.38	5.75	6.40	7.08	6.98
	Panicum	6.19	6.97	7.58	6.42	8.9	10.16	11.01	10.81
10t/ha	*Chromolaena*	5.06	5.63	6.02	5.26	6.97	7.88	8.43	8.33
	Glycine	7.36	8.15	9.12	7.76	10.51	11.81	13.17	12.95
	Panicum	11.39	12.94	14.16	11.83	16.81	19.82	21.02	20.63
LSD(R)		NS	x	x	x	x	x	x	x
LSD (T)		NS	x	x	x	x	x	x	x
LSD (R x T)		NS	x	NS	x	x	x	x	x

NS = not significant, x = P≤0.05, WAP = Weeks After planting

Table 14: Effects of mulching with plant materials on number of pod(s) of okra plant during both planting.

Rate	Residue	First	Planting		Second	Planting	
		12	14	16	12	14	16
		-⑧	WAP	->>	_>	WAP	__>>
t/ha	Control	6	10	4	9	9	11
t/ha	*Chromolaena*	7.88	8.33	8.74	6.46	6.26	5.87
	Glycine	8.67	9.59	8.11	34.01	35.55	30.88
	Panicum	14.11	15.76	12.73	10.16	11.01	39.16
0t/ha	*Chromolaena*	10.67	11.42	9.94	9.25	9.64	8.44
	Glycine	16.33	18.18	15.22	67.01	70.09	60.54
	Panicum	27.21	29.53	24.47	19.52	21.02	77.31
.SD(R)		x	NS	x	x	x	x
.SD (T)		x	NS	x	x	x	x
.SD (R x T)		x	NS	NS	x	x	x

NS = not significant, x = P≤0.05, WAP = Weeks After planting

Table 15: Effects of mulching with plant materials on weight of pods (g) inOkra plant during both planting.

Rate	Residue	First	Planting		Second	Planting	
		12	14	16	12	14	16
		-⑧	WAP	->>	_>	WAP	__>>
'ha	Control	44.50	53.70	46.80	59.20	63.30	76.40
ha	*Chromolaena*	12.99	25.30	21.20	36.29	38.04	30.17
	Glycine	30.70	32.49	28.26	40.61	53.39	53.37
	Panicum	238.63	252.91	219.04	281.65	354.89	313.23
:/ha	*Chromolaena*	22.47	39.99	33.64	58.48	60.99	47.79
	Glycine	60.41	63.98	55.52	80.02	106.18	105.75
	Panicum	496.26	504.82	437.14	407.04	439.48	380.23
D(R)		x	X	x	x	x	x
D (T)		x	X	x	x	x	x
D (R x T)		x	X	x	x	x	x

NS = not significant, x = P≤0.05 and WAP = Weeks After planting

Conclusion

Mulching with siam weed enhanced the highest vegetative growth at both planting periods. Similarly, guinea grass mulching gave added advantage of significance lower number of days to flowering. Thus, the use of guinea grass encouraged the optimum yield of okra fruit at both planting. Mulching with soybean encouraged higher pods formation in okra plants at both planting periods. Plant residues at 10t/ha can be used at planting for the release of needed nutrients for effective performance of okra plant. Therefore, the application of siam weed at 10 t/ha as mulch should be considered for vegetative growth and high pod production of okra. For higher fruits of okra production, the use of 10 t/ha of guinea grass as mulch material is thus recommended for higher fruit production in the region of investigation.

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