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INFLUENCE OF WEED CONTROL PRACTICES ON THE GROWTH AND YIELD OF HOLY BASIL (*Ocimum sanctum*) IN NSUKKA DERIVED SAVANNA

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ABSTRACT
The effect of weed control methods on the growth and yield of holy basil (*Ocimum sanctum*) was evaluated in the field from October 2019 to February 2020 at the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka located in the derived savanna agro-ecology of Southeastern Nigeria. The experiment was carried out to evaluate the effect of nine weed management methods on the growth and yield of holy basil. The treatments were: post-emergence application of haloxyfop at 0.2 kg a.i./ha sprayed at 30 days after transplanting, weed-free, hoe weeding at 30 days after transplanting, mulch with transparent polyethylene, mulch with black polyethylene, mulch with red polyethylene, mulch with sawdust, mulch with rice husk and weedy plot as control. The experiment was laid out in a randomized complete block design (RCBD) with three replications. Data were collected on the growth and yield parameters and also on weed density and biomass. The data were analyzed using (Genstat) at a 5% level of probability. The result showed a significant effect ($p<0.05$) of the treatments on the growth and yield parameters of holy basil. Rice husk mulched plots gave significantly higher growth parameters throughout the experiment but with the least plant establishment while black polyethylene mulch gave the least weed population, weed fresh weight, and weed dry weight and higher yield. Therefore, the use of black polyethylene and rice husk mulch should be adopted for better growth and yield of holy basil.

Keywords: Weed control, weed biomass, weed dry weight, yield, holy basil

INTRODUCTION
Holy basil (*Ocimum sanctum*) is a flowering plant of the mint family (*Lamiaceae)* grown for its aromatic leaves. It is also called *tulsi* or*tulasi*. O. sanctum derives its species name from the Latin word for 'sacred'. Its current accepted name, *'tenuiflorum'*, refers to its slender flowers (Smith, 1971; Stearn, 1992).

Basil is native to areas in Asia and Africa and grows wild as a perennial on some Pacific Islands. It was brought from India to Europe through the Middle East in the sixteenth century. O. *tenuiflorum is now* grown in tropical and subtropical regions, primarily cultivated in agricultural settings, home gardens, as well as around temples and places of worship, especially in India and Malaysia (Globinmed, 2014).

Holy basil is used as a condiment in salads and other foods, and also as a substitute for tea (Flora of China Editorial Committee, 2014). Traditional uses of holy basil as medicine include the treatment of abdominal issues, oral infections, cough, colds, tumors and cancer, digestive tract problems, respiratory inflammation, arthritis, asthma, ulcers, wounds, hypoglycemia, bronchitis, urinary issues, cardiovascular problems and many others (Das and Vasudevan, 2006; Mondal *et al.,* 2009; Mohan *et al*., 2011 and Kumar *et al.,* 2013). Although the whole plant is medicinally important, the leaves are generally the most common form of usage, and are either used raw or steeped in hot water. The medicinal properties of holy basil leaves include: antimicrobial, anticancer, antistress, adaptogenic stimulant, expectorant, nervine, antipyretic and antiperiodic (Engels and Rnckmann, 2013). One of the problems affecting the growth and yield of this crop is weed. Weeds are plants which its populations enter cultivated habitats, disturb and potentially depress or displace the resident plant populations which are deliberately cultivated or are of ecological interest (Navas, 1991). It is impossible to sow a crop without the certainty that other plants (weeds) will appear (Brenchley, 1917). It is clear that competition is the most important factor in determining the impact of weeds on crop yield (Bastiaans *et al.,* 2008). Based on weed characteristics, weeds compete with crops at every stage of growth for nutrients, moisture, light and space thus reducing the quality and quantity of the final product (Moolani and Sachan, 1966). In order to assess the effects (including the economic aspects) of any weed management practice, it is necessary to understand the impact of weeds on a given crop (Upadhyaya and Blackshaw, 2007).

Most vegetable crops are slow growing and have poor canopy development during the early stages. This habit makes them susceptible to competition from weeds, which adversely affect yield and quality of these crops. Weeds compete with crops for water, nutrients, space, light and oxygen resulting into a delay in maturity and low yield (Njoroge, 1999).

Weed control has been observed as one of the most important practices in crop production because good weed control will ensure maximum yield and high quality of farm produce (Njoroge, 1999). Since most vegetable crops are very slow in growth, especially in the early stages of their establishment, it becomes important to begin weed control early enough in order to ensure high yield and quality because weeds harbor pests from season to season.

Holy basil is still on the subsistence level of production and not widely grown. One of the problems limiting its production is weed control. Therefore, there is a need to improve the agronomic practices in the production of this crop especially its weed control to enable farmers embark on its production, bearing in mind its numerous benefits. Therefore, the objective of the study was to ascertain the effect of different weed control methods on the growth and yield of holy basil.

MATERIALS AND METHODS

Study Area

The experiment was conducted at the Teaching and Research Farm of Department of Crop Science, University of Nigeria, Nsukka. The research farm lies on Latitude 06^0 51'N and longitude 07^0 23'E at an altitude of 423m above sea level.

Land preparation

A field measuring 13 m by 5 m was used for the experiment. The land was cleared manually with the use of cutlasses. The land was cleared of stumps and weeds; it was then divided into three blocks and into plots measuring 1 m by 1 m. Each block was separated from the other by a distance of 1 m. Each plot was separated from the other with 0.5 m distance apart.

The seeds of Holy basil were raised in a nursery basket for one month before transplanting. The nursery medium was prepared with top soil, poultry manure and river sand in the ratio of 3: 2: 1. Poultry manure was added to each plot at the rate of 20,000 kg/ha and mixed thoroughly with the soil before transplanting. The seedlings were transplanted to the already prepared beds on the field one month after planting.

Experimental Design and Treatments

The holy basil seedlings were transplanted to the field on raised beds measuring 1 m by 1 m using plant spacing of 40 cm by 40 cm. Nine (9) treatments comprising of post emergence application of haloxyfop at 0.2 kg a.i./ha sprayed at 30 days after transplanting (DAT), weed free, hoe weeding at 30 days after transplanting (DAT), mulch with transparent polyethylene, mulch with black polyethylene, mulch with red polyethylene, mulch with sawdust (120,000 kg/ha), mulch with rice husk (180,000 kg/ha), and weedy plot as control were laid out in a randomized complete block design (RCBD) with three replications.

Data collection

Weed data

Weed identification: Weed encountered in the different treatments was identified to species level using a handbook of West African Weeds (Akobundu *et al*., 2016). Weed biomass: Population count of identified weeds per plot was done using a quadrat of 0.5 m^2 placed randomly at two different spots in the plot. The data on weed density and weed infestation was collected from each unit at 2^{nd}, 6^{th} and 10^{th} weeks after transplanting.

Weed density: The weeds identified were harvested from the base and categorized and then weighed on an electric balance (in grams) to get the fresh weight. Thereafter, it was dried in an electric oven at 80^0C for 48 hours and the dry weight was recorded. The weed control efficiency was calculated with the following formula by Mani *et al*. (1973);

$$\text{Weed control efficiency (WCE)} = \frac{\text{DMC-DMT}}{\text{DMC}} \times 100$$

Where: DMC = weed dry matter production in un-weeded treatment, DMT = weed dry matter production in weed control treatment. Weed Index (WI) was calculated with the following formula by Mishra and Tosh, (1979);

$$\text{WI (\%)} = \frac{\text{Average yield of crop in weed free plot} - \text{Average yield of crop in weed control treatment}}{\text{Average yield of crop in weed free plot}} \times 100$$

Plant growth parameters

Two plants each were selected from the middle row for data collection on plant growth parameters which was done at two weekly intervals. .Plant establishment: This was done by counting the number that survived per plot at regular intervals. Number of leaves per plant: The total number of leaves per sample plant was counted for each treatment and the average recorded.

Number of branches per plant: The total number of branches per sample plant was counted for each treatment and the average recorded. Plant height: The height of each sampling plant was measured in centimeters (cm), from base to the top of the plant. Canopy diameter per plant: This was done by taken the length and breadth of the canopy coverage for each sample plant in each plot divided by two and the average recorded. Stem girth per plant: The girth of the stem of each sampling plant was measured in centimeter (cm) with the help of venier caliper and the average recorded. Crop yield per plant: The leave yield from each sample plant was harvested and recorded and the average taken. Crop yield per plot: The leave yield from each plot was recorded.

Data analysis

All the data collected were subjected to analysis of variance (ANOVA) following one-way procedure for RCBD experiments using Genstat Release 12.1 Discovery Edition (2009). Weed data were first transformed with square root transformation method before the statistical analysis was carried out. Mean separation across the treatments were done using Fisher's Least Significant Difference at 5% probability level ($LSD_{0.05}$).

RESULTS

Composition of weed species in the experimental plot

A total of eight (8) weed species were observed in the different weed control treatments (Table 1). The weed species were mostly broad-leaved weeds while *Eleusineindica* and *Cyperusrotundus* were only weed species recorded as grass and sedge respectively. About seventy-seven percent (77.8%) of the weed species encountered were broadleaves, 11.1% were grasses while sedges were 11.1% and the entire weed species were annuals. At 2 weeks after transplanting (WAT), *Euphorbia heterophylla* and *Eleusineindica*, had more occurrence throughout the different weed control treatments while other weed species occurred sparingly and some were absent in some treatments. At 6 WAT, there was a reduction in the occurrence of the weeds due to the effect of the different treatments. Some of the identified weed species were less severe as observed in black polyethylene mulch, hoe weeding at 30 days after transplanting (DAT), postemergence application of haloxyfop and weed free. It could be observed that at 10 WAT, there was a total suppression of the weed species in the plots mulched with black polyethylene while less occurrence of the various weeds was observed in other weed control treatments except in the weedy plots and the plots mulched with transparent polyethylene.

Effect of weed control treatments on weed density and biomass

At 2 WAT, the effect of weed control methods on weed population shows significant difference($p<0.05$) on the number of broadleaves, weed dry weight and weed control efficiency (Table 2). Weedy plot recorded significantly ($p<0.05$) higher number of broad leaves ($7.51/0.5m^2$) while the least was recorded in plots mulched with sawdust ($4.29/0.5m^2$). Weedy plots recorded significantly ($p<0.05$) higher weed dry weight (2.70 g) while the least weed dry weight (0.37 g) was recorded in plots mulched with black polyethylene. Significantly ($p<0.05$) higher weed control efficiency was recorded in black polyethylene mulched plots (87%) while the least was recorded in weedy plots (0.0%). There was no significant difference ($p>0.05$) on the number of grasses, number of sedges and fresh weight of the weeds recorded among the weed treatments.

At 6 WAT, transparent polyethylene mulched plots gave significantly ($p<0.05$) higher number of broad-leaved weeds ($5.90/0.5m^2$) while the least ($1.43/0.5m^2$)) was recorded in hoe weeded plots at 30 DAT (Table 3). Red polyethylene mulched plots recorded significantly ($p<0.05$) higher number of grasses ($4.29/0.5m^2$) and the least was recorded by plots with postemergence application of haloxyfop ($0.71/0.5m^2$). Significantly higher weed dry weight (58.23 g) and lower weed control efficiency (0.0%) was recorded by weedy plots while lower weed dry weight (0.47 g) and higher control efficiency (99.2%) was recorded by hoe weeded plots. There was no significant difference ($p>0.05$) on the number of sedges and fresh weight.

At 10 WAT, weedy plots recorded significantly ($p<0.05$) higher number of broadleaves ($4.12/0.5m^2$), weed fresh weight (105.6 g), weed dry weight (31.13 g) and lower weed control efficiency (0.0%) while least number of broadleaved weeds, weed fresh weight, weed dry weight and higher weed control efficiency was consistently recorded in black polyethylene mulched plots (Table 4). There was no significant difference of the treatments on the number of grasses and number of sedges.

Effect of weed control treatments on morphological parameters

At 2 weeks after transplanting, the canopy diameter was significantly ($p < 0.05$) higher in rice husk mulched plots (8.50 cm) which was statistically similar to that of transparent polyethylene mulched plots (6.46 cm) but differed significantly from those of other weed control treatments while the least was obtained in weedy plots (3.42 cm) (Table 5). The weed control treatments did not differ significantly ($p>0.05$) on the number of branches, number of leaves, plant height, plant establishment and stem girth at two weeks after transplanting, however, rice husk mulched plots had the highest number of branches (8.67) and number of leaves (72.50) and stem girth (0.73 cm), while transparent polyethylene mulched plots had the highest value for plant height (12.83 cm). In terms of plant establishment, all of them were established (9.00) per plot. At 4 weeks after transplanting, the canopy diameter, plant establishment and stem girth varied significantly ($p < 0.05$) (Table 4). Rice husk mulched plots recorded significantly ($p<0.05$) higher value for canopy diameter (33.50 cm) and stem girth (1.43 cm), while the least for these parameters was obtained in post emergence (PE) application of haloxyfop (12.0 cm) and (0.75 cm) respectively.PE application of haloxyfop recorded significantly ($p<0.05$) higher plant establishment (9.0) which was similar to those of red polyethylene mulched plots (9.0), weedy plots (9.0) and transparent polyethylene mulched plots (9.0), while the least was obtained in rice husk mulched plots (6.00).

Table 1: The predominant weed species based on the treatments and their preponderance

Weed Management	Weeds present	2 weeks	6 weeks	10 weeks
Black polyethylene mulch	*Calopogoniummuconoides*	++	+	-
	*Mimosa invisa*Mart	+	+	-
	Mitracarpusvillosus	+	+	-
	*Euphorbia heterophylla*Linn.	++	+	-
	Eleucineindica	++	+	-
	Cyperusrotundus	+	+	-
Hoe weeding at 30 DAT	*Calopogoniummuconoides*	++	+	+
	Mimosa invisaMart	+	-	+
	Mitracarpusvillosus	+	+	++
	*Euphorbia heterophylla*Linn	+++	-	+
	Celosia leptostachymaBenth	++	+	++
	Ageratum conyzoides	+	-	+
	Eleucineindica	++	+	+
	Cyperusrotundus	++	+	+
P.E spray of haloxyfop	*Calopogoniummuconoides*	+	+	+
	*Mimosa invisa*Mart	+	-	+
	Mitracarpusvillosus	+	++	+++
	*Euphorbia heterophylla*Linn	+++	+	-
	Celosia leptostachymaBenth	++	-	+
	Cyperusrotundus	+	++	++
Rice husk mulch	*Calopogoniummuconoides*	-	+	+
	*Mimosa invisa*Mart	-	++	++
	Mitracarpusvillosus	++	+	-
	*Euphorbia heterophylla*Linn	++	++	+
	Ageratum conyzoides	-	++	-
	Eleucineindica	+++	+	-
	Cyperusrotundus	+	+	+
Red polyethylene mulch	*Calopogoniummuconoides*	++	+++	
	*Mimosa invisa*Mart	+	+	++
	Mitracarpusvillosus	+	++	--
	*Euphorbia heterophylla*Linn	+++	-	++
	Eleucineindica	++	+++	-
	Cyperusrotundus	++	+	+++
				++
		++	++	++
sawdust mulch	*Calopogoniummuconoides*			
	*Mimosa invisa*Mart	-	+	+
	Mitracarpusvillosus	+	++	++
	*Euphorbia heterophylla*Linn	++	+	+
	Eleucineindica	+	-	-
	Cyperusrotundus	+	+	+
Weedy plot	*Calopogoniummuconoides*	++	++	++
	*Mimosa invisa*Mart			
	Mitracarpusvillosus	+	+	+
	*Euphorbia heterophylla*Linn	++	++	++
	*Ageratum conyzoides*Benth	+++	+	++
	*Sidaacuta*Burm	++	+++	++
	Eleucineindica	++	+	++
	Cyperusrotundus	+++	++	+
		+++	++	+
Weed free	*Calopogoniummuconoides*	+++	++	++
	*Mimosa invisa*Mart	+	+	+
	Mitracarpusvillosus	+	-	-
	*Euphorbia heterophylla*Linn	+++	--	--
	Eleucineindica	++	+	+
	Cyperusrotundus	+	+	+
Transparent polyethylene mulch	*Calopogoniummuconoides*	+++	+++	+++
	*Mimosa invisa*Mart	+	+	
	Mitracarpusvillosus	+	++	+
	*Euphorbia heterophylla*Linn	++	++	-
	Eleucineindica	+++	+++	++
	Cyperusrotundus	+	+	+++
				+

+ = Less severe, ++= Severe, +++ = More severe, - =Weed absent.

Table 2: The effect of weed control methods on weed data at 2 weeks after transplanting

Weed Management	NBL/0.5m^2	NG/0.5m^2	NS/0.5m^2	WFW(g)	WDW (g)	WCE(%)
BPM	23.30 (4.84)	8.70 (2.93)	0.33 (0.88)	2.33	0.37	87.00
HW	30.00 (5.46)	6.00 (2.46)	0.33 (0.88)	8.83	1.10	60.30
PEH	43.30 (6.58)	9.70 (2.73)	0.33 (0.88)	5.30	0.80	70.70
RHM	20.00 (4.29)	7.30 (2.41)	0.00 (0.71)	2.17	0.33	88.10
RPM	25.30 (4.95)	7.30 (2.41)	3.00 (1.68)	3.17	0.70	73.40
SDM	18.00 (4.29)	2.30 (1.68)	0.33 (0.88)	5.47	0.80	71.20
WDY	56.30 (7.51)	8.70 (2.98)	5.33 (1.96)	12.13	2.70	0.00
WF	53.30 (7.18)	8.30 (2.53)	2.33 (1.68)	9.87	2.13	21.80
TPM	35.70 (5.89)	17.00(4.12)	1.67 (1.35)	9.43	1.63	38.40
Mean	5.66	2.69	1.35	6.52	1.17	56.80
F-LSD$_{(0.05)}$	1.95	n.s	n.s	n.s	0.71	25.70

NBL = number of broad leaves, NG = number of grasses, NS = number of sedges, WFW = Weed fresh weight, WDW = weed dry weight, WAT = week after transplanting, DAT = days after transplanting, NB: the transformed value is in parentheses, CD= Canopy diameter, NB/plt = Number of branches per plant, PH = Plant height, PE = Plant Establishment, SG = Stem girth, BPM = Black polyethylene mulch, HW = Hoe weeding at 30 days after transplanting (DAT), PEH = Post emergence application of haloxyfop, RHM = Rice husk mulch, RPM = Red polyethylene much, SDM = Sawdust mulch, WDY = Weedy plot, WF = Weed free plot, TPM = Transparent polyethylene mulch, ns = Not significant.

Table 3: The effect of weed control methods on weed data at 6 weeks after transplanting

Weed Management	NBL/0.5m^2	NG/0.5m^2	NS/0.5m^2	WFW (g)	WDW (g)	WCE (%)
BPM	2.70 (1.56)	2.70 (1.64)	1.33 (1.18)	6.00	2.58	95.50
HW	2.00 (1.43)	3.30 (1.55)	0.00 (0.71)	1.00	0.47	99.20
PEH	12.00 (3.49)	0.00 (0.71)	1.33 (1.18)	68.00	12.90	77.60
RHM	11.00 (3.30)	3.70 (1.72)	6.33 (2.26)	219.00	32.40	43.60
RPM	21.00 (4.62)	25.00 (4.29)	1.33 (1.18)	152.00	38.83	30.20
SDM	21.70 (4.62)	1.30 (1.34)	1.33 (1.27)	159.00	27.27	54.00
WDY	16.70 (3.98)	10.71 (3.28)	6.33 (1.94)	233.00	58.23	0.00
WF	5.30 (2.17)	1.30 (1.18)	0.67 (1.00)	4.00	1.87	96.70
TPM	35.00 (5.90)	16.70 (4.00)	1.00 (1.17)	144.00	24.43	57.50
Mean	3.45	2.19	1.32	110.00	22.11	61.60
F-LSD$_{(0.05)}$	1.86	2.35	n.s	n.s	7.83	12.53

NBL = number of broad leaves, NG = number of grasses, NS = number of sedges, WFW = Weed fresh weight, WDW = weed dry weight, WAT = week after transplanting, DAT = days after transplanting, NB: the transformed value is in parentheses, CD= Canopy diameter, NB/plt = Number of branches per plant, PH = Plant height, PE = Plant Establishment, SG = Stem girth, BPM = Black polyethylene mulch, HW = Hoe weeding at 30 days after transplanting (DAT), PEH = Post emergence application of haloxyfop, RHM = Rice husk mulch, RPM = Red polyethylene much, SDM = Sawdust mulch, WDY = Weedy plot, WF = Weed free plot, TPM = Transparent polyethylene mulch, ns = Not significant.

There was no significant difference on the number of branches, number of leaves and plant height at 4 weeks after transplanting, however red polyethylene mulch had the highest number of branches (16.50), rice husk mulched plot had the highest number of leaves (94.17) and plant height (24.83 cm) respectively. At 6 WAT, the canopy diameter was Ignificantly ($p < 0.05$) higher in rice husk mulched plots (44.9 cm) while the least was obtained in plots with PE application of haloxyfop (19.3 cm) (Table 6). Number of leaves was significantly ($p < 0.05$) higher in rice husk mulched plots (141.8) while the least was obtained in weedy plots (45.7). Plant establishment was significantly ($p < 0.05$) higher on plots with PE application of haloxyfop (9.0) which was similar with those of red polyethylene mulched plots (9.0) and transparent polyethylene mulched plots (9.0) while the least was obtained in rice husk mulched plots (5.33). There was no significant different ($p>0.05$) on the number of branches, plant height and stem girth however, rice husk mulched plots recorded higher number of branches (42.00), plant height (38.8 cm) and stem girth (1.98). At 8 WAT, canopy diameter, number of leaves and plant establishment were significant. Rice husk mulched plots recorded significantly ($p <0.05$) higher canopy diameter (46.7 cm) and number of leaves (189.0), while

Table 4: The effect of weed control methods on weed data at 10 weeks after transplanting

Weed Management	NBL/0.5m^2	NG/0.5m^2	NS/0.5m^2	WFW (g)	WDW (g)	WCE(%)
BPM	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00	0.00	100
HW	5.70 (2.45)	3.67 (2.00)	0.00 (0.71)	5.50	1.33	95.70
PEH	14.00 (3.77)	0.33 (0.88)	6.33 (2.21)	76.50	9.93	68.00
RHM	4.30 (2.12)	1.67 (1.25)	0.00 (0.71)	43.60	8.53	72.60
RPM	11.70 (3.33)	11.33 (3.02)	4.67 (2.06)	55.50	10.23	67.30
SDM	10.00 (2.81)	0.33 (0.88)	0.00 (0.71)	101.18	14.20	54.40
WDY	16.70 (4.12)	6.67 (2.50)	0.67 (1.00)	105.60	31.13	0.00
WF	1.70 (1.25)	2.33 (1.54)	0.00 (0.71)	5.60	1.27	96.00
TPM	14.30 (3.84)	4.33 (2.20)	1.00 (1.17)	79.50	15.87	48.90
Mean	2.71	1.66	1.11	54.80	10.28	67.00
F-LSD$_{(0.05)}$	1.64	n.s	n.s	68.97	6.75	21.88

NBL = number of broad leaves, NG = number of grasses, NS = number of sedges, WFW = Weed fresh weight, WDW = weed dry weight, WAT = week after transplanting, DAT = days after transplanting, NB: the transformed value is in parentheses, CD= Canopy diameter, NB/plt = Number of branches per plant, PH = Plant height, PE = Plant Establishment, SG = Stem girth, BPM = Black polyethylene mulch, HW = Hoe weeding at 30 days after transplanting (DAT), PEH = Post emergence application of haloxyfop, RHM = Rice husk mulch, RPM = Red polyethylene much, SDM = Sawdust mulch, WDY = Weedy plot, WF = Weed free plot, TPM = Transparent polyethylene mulch, ns = Not significant.

Table 5: The effect of different weed control methods on the morphological parameters of holy basil at 2 and 4 weeks after transplanting

Weed Managemen t	**CD (cm)**	**NB/plt**	**NL/plt**	**PH (cm)**	**PE**	**SG (cm)**	**CD (cm)**	**NB/plt**	**NL/plt**	**PH (cm)**	**PE**	**SG(cm)**
	Weeks after transplanting											
	2						**4**					
BPM	4.33	7.00	48.80	11.17	9.00	0.72	24.67	15.67	65.33	25.67	8.67	1.24
HW	6.00	6.67	37.5	6.50	9.00	0.55	14.42	12.67	46.50	12.17	8.67	1.00
PEH	4.00	4.33	33.0	5.67	9.00	0.51	12.00	9.67	38.83	13.67	9.00	0.75
RHM	8.50	8.67	72.5	10.83	9.00	0.73	33.50	15.17	94.17	24.83	6.00	1.43
RPM	5.00	7.33	53.8	12.33	9.00	0.67	20.00	16.50	71.00	18.00	9.00	0.86
SDM	5.92	6.67	32.5	6.83	9.00	0.54	22.17	15.33	47.17	18.00	7.33	0.93
WDY	3.42	4.17	33.3	9.00	9.00	0.64	13.17	11.33	43.50	12.83	9.00	0.82
WF	4.83	7.83	49.0	12.17	9.00	0.57	18.00	14.00	63.00	17.33	8.00	1.10
TPM	6.46	7.83	56.7	12.83	9.00	0.47	23.08	15.67	82.50	24.17	9.00	1.10
Mean	5.38	6.72	46.4	9.70	9.00	0.60	20.11	14.00	61.33	26.30	8.30	1.03
F-LSD$_{(0.05)}$	2.26	n.s	n.s	n.s	n.s	n.s	10.89	n.s	n.s	n.s	1.01	0.37

CD= Canopy diameter, NB/plt = Number of branches per plant, PH = Plant height, PE = Plant Establishment, SG = Stem girth, BPM = Black polyethylene mulch, HW = Hoe weeding at 30 days after transplanting (DAT), PEH = Post emergence application of haloxyfop, RHM = Rice husk mulch, RPM = Red polyethylene much, SDM = Sawdust mulch, WDY = Weedy plot, WF = Weed free plot, TPM = Transparent polyethylene mulch, ns = Not significant.

Table 6: The effect of different weed control methods on the morphological parameters of holy basil at 2 and 4 weeks after transplanting

Weed management	**CD (cm)**	**NB/plt**	**NL/plt**	**PH (cm)**	**PE**	**SG (cm)**	**CD (cm)**	**NB/plt**	**NL/plt**	**PH (cm)**	**PE**	**SG(cm)**
	Weeks after transplanting											
	6						**8**					
BPM	34.20	36.50	79.80	35.80	8.67	1.29	31.80	43.30	119.00	38.20	8.00	1.92
HW	24.30	16.20	62.30	24.20	8.33	1.51	29.30	25.00	96.80	28.80	8.33	1.61
PEH	19.30	13.20	48.70	25.20	9.00	1.15	21.80	19.50	58.20	24.50	9.00	1.26
RHM	44.90	42.00	141.80	38.80	5.33	1.98	46.70	44.10	189.00	40.00	5.33	2.51
RPM	23.90	37.30	71.00	37.30	9.00	1.33	24.30	26.50	77.00	39.80	9.00	1.37
SDM	33.50	22.80	68.00	34.80	7.33	1.60	36.20	27.50	83.20	38.70	7.33	1.63
WDY	19.70	25.80	45.70	22.50	8.67	1.20	20.90	20.20	57.00	26.80	8.67	1.33
WF	27.70	23.80	72.50	29.20	7.67	1.47	29.40	30.00	86.70	32.00	7.67	1.64
TPM	28.60	38.80	79.00	37.50	9.00	1.52	26.70	29.00	82.80	38.30	9.00	2.08
Mean	28.50	28.50	74.30	31.70	8.11	1.78	29.70	29.50	94.40	34.10	8.04	1.71
F-LSD$_{(0.05)}$	13.50	n.s	50.87	n.s	0.98	n.s	13.60	n.s	56.55	n.s	0.99	n.s

CD= Canopy diameter, NB/plt = Number of branches per plant, PH = Plant height, PE = Plant Establishment, SG = Stem girth, BPM = Black polyethylene mulch, HW = Hoe weeding at 30 days after transplanting (DAT), PEH = Post emergence application of haloxyfop, RHM = Rice husk mulch, RPM = Red polyethylene much, SDM = Sawdust mulch, WDY = Weedy plot, WF = Weed free plot, TPM = Transparent polyethylene mulch, ns = Not significant.

the least for both parameters was obtained in weedy plots (20.9) and (57.0) respectively. Plant establishment was significantly ($p < 0.05$) higher on plots with PE application of haloxyfop (9.00) which was the same as recorded in red polyethylene mulched plots (9.0) and transparent polyethylene mulched plots (9.0) while the least was obtained in rice husk mulched plots (5.33).

There was no significant difference ($p>0.05$) on the number of branches, plant height and stem girth but the highest number of branches, plant height and stem girth were obtained in rice husk mulched plots (44.10, 40.00 and 2.51) respectively.

At 10 WAT, the canopy diameter and number of leaves were significantly ($p < 0.05$) higher on rice husk mulched plots (53.0 cmand 196.70) respectively while the least for these parameters was obtained in weedy plots (23.7 cm and 64.2) respectively (Table 7). Plant establishment was significantly ($p < 0.05$) higher on plots with PE application of haloxyfop (9.00) which was similar to those recorded in red polyethylene mulched plots (9.0) and transparent polyethylene mulched plots (9.0) while the least was obtained in rice husk mulched plots (5.33). Stem girth was significantly ($p < 0.05$) higher on rice husk mulched plots (2.52 cm) while the least was obtained in PE application of haloxyfop plots (1.38 cm). There was no significant difference ($p>0.05$) on the number of branches and plant height however, rice husk mulched plots gave the highest value for these parameters (48.80 and 41.0 cm) respectively.At 12 WAT, the canopy diameter was significantly ($p < 0.05$) higher on rice husk mulched plots (53.7 cm) which was statistically similar to that of black polyethylene mulched plots (39.6 cm) while the least was obtained in weedy plots (25.2 cm). Plant establishment was significantly ($p < 0.05$) higher on plots with PE application of haloxyfop (9.0) which was similar to that of red polyethylene mulched plots (9.0) and transparent polyethylene mulched plots (9.0) while the least was obtained in rice husk mulched plots (5.33). There was no significant different ($p>0.05$) on the number of branches, plant height and stem girth but rice husk mulched plots gave the highest number of branches (50.50) which was similar to that recorded in black polyethylene mulched plots (50.50). The highest value for plant height was obtained in black polyethylene mulched plots (42.0 cm), while the highest value for stem girth was obtained in rice husk mulched plots (2.76 cm). Rice husk mulched plots recorded significantly ($p<0.05$) higher number of leaves (206.8) which was statistically similar to those of black polyethylene mulched plots (165.0) and hoe weeded plots (131.2) while the least was recorded in weedy plots (68.0).

DISCUSSION

The effect of weed control methods on weed data

Weed species diversity was higher in hoe weeded plots, rice husk mulched plots, postemergence application of haloxyfop, hoe weeded plots and weedy plots. This indicates that weed flora composition was being altered by weed control practices studied. This agrees with the result of the findings of Osadebe*et al*. (2015) and Naeem *et al*. (2022) that farming practices influence the species composition of weed communities in arable fields. The highest fresh and dry weight of weed occurred on the weedy check plots while black polyethylene mulched plots had the least. It is known that black polyethylene film cover provides a good weed control (Sanders, 2001). This agrees with Li *et al.* (2012) who reported that protecting crops under plastic (polyethylene) generates changes in the environmental conditions of light, temperature and relative humidity that may have effect on the yield. Mamkagh(2009) noted that using plastic mulch as soil coverage enhanced the vegetative growth and yield of okra.

Black polyethylene mulch had the lowest weed infestation and was seen to be effective in weed suppression because weeds could only be seen just around the opening where the crop was planted. The reason for lower weed dry weight in the black polyethylene mulch compared to weed free plots was attributed to poor light transmittance in black polyethylene mulch, which resulted in reduced photosynthetic activity of the weeds. This was properly explained by the report of Anyakoha (2010) who suggested that darker surfaces are also a better absorber of heat, does not allow complete absorption of sunrays, the heat generated also smoulders weed seeds and weed seedlings making them unable to survive. This also may be ascribed to reduced nutrient loss due to weed control and improved hydrothermal regimes of soils (Singh, 2005). Similar finding of plastic mulch suppressing growth have been reported by Zhao *et al*. (2012). The result of the findings is in agreement with the report of Ngouajio*et al*. (2004) and Osadebe*et al*. (2015) that there was complete elimination of weeds with the use of black polyethylene mulch. Black polyethylene mulch reduced weed emergence and checked weed growth by intercepting all-incoming radiation (Schonbeck, 1999).

Table 7: The effect of different weed control methods on the morphological parameters of holy basil at 6 and 8 weeks after Transplanting

Weed management	CD (cm)	NB/plt	NL/plt	PH (cm)	PE	SG(cm)	CD (cm)	NB/plt	NL/plt	PH (cm)	PE	SG (cm)
	WEEKS AFTER TRANSPLANTING											
	10						12					
BPM	36.30	48.30	151.70	40.80	8.00	2.28	39.60	50.50	165.00	42.00	8.00	2.59
HW	35.60	29.70	126.00	32.50	8.33	1.76	36.40	31.20	131.20	33.70	8.33	1.87
PEH	25.80	21.30	66.00	27.50	9.00	1.38	27.80	24.00	100.20	38.00	9.00	1.79
RHM	53.00	48.80	196.70	41.00	5.33	2.52	53.70	50.50	206.80	41.70	5.33	2.76
RPM	26.70	29.90	83.50	39.50	9.00	1.66	27.30	30.30	84.50	41.20	9.00	1.78
SDM	39.10	38.30	98.70	40.80	7.33	2.11	38.80	36.30	106.50	40.80	7.33	2.03
WDY	23.70	23.50	64.20	29.30	8.67	1.54	25.20	24.70	68.00	29.80	8.67	1.67
WF	36.20	32.20	91.50	32.20	7.67	1.94	37.50	33.80	98.80	33.20	7.67	2.05
TPM	28.70	29.70	82.80	31.60	9.00	1.85	31.00	29.70	83.50	37.80	9.00	2.06
Mean	33.90	33.50	106.80	35.00	8.04	1.89	35.20	34.60	116.10	37.60	8.04	2.07
F-LSD$_{(0.05)}$	14.30	n.s	73.30	n.s	0.99	0.65	14.19	n.s	80.04	n.s	0.99	n.s

CD= Canopy diameter, NB/plt = Number of branches per plant, PH = Plant height, PE = Plant Establishment, SG = Stem girth, BPM = Black polyethylene mulch, HW = Hoe weeding at 30 days after transplanting (DAT), PEH = Post emergence application of haloxyfop, RHM = Rice husk mulch, RPM = Red polyethylene much, SDM = Sawdust mulch, WDY = Weedy plot, WF = Weed free plot, TPM = Transparent polyethylene mulch, ns = Not significant.

Table 8: The effect of weed control methods on yield data at 12 weeks after transplanting

Weed Management	Yield per plant (g)	Yield per plot (g)	Weed Index (%)
BPM	113.20	578.00	-101.70
HW	62.70	502.00	-84.60
PEH	24.70	225.00	25.80
RHM	104.40	545.00	-79.40
RPM	31.80	158.00	47.60
SDM	56.00	352.00	-17.60
WDY	31.10	188.00	35.60
WF	37.00	298.00	0.00
TPM	25.50	171.00	43.10
Mean	54.00	335.00	-14.60
F-LSD$_{(0.05)}$	42.08	233.50	80.49

BPM = Black polyethylene mulch, HW = Hoe weeding at 30 days after transplanting (DAT), PEH = Post emergence application of haloxyfop, RHM = Rice husk mulch, RPM = Red polyethylene much, SDM = Sawdust mulch, WDY = Weedy plot, WF = Weed free plot, TPM = Transparent polyethylene mulch, ns = Not significant.

The effect of weed control methods on the morphological parameters of holy basil

From the study, it was observed that the use of mulching materials affected the growth and yield of holy basil. The increase in plant height, stem girth, number of branches, number of leaves and canopy diameter observed in this study is consistent with the findings of Mamkagh (2009) which states that covering the soil with mulch materials increased the morphological parameters compared with bare soil which might be due to increased soil temperature (Tuli and Yesiloy, 1997). Observations on plant growth showed that the holy basil plants in mulched plots were generally tall, have thicker stem girth and produced the highest number of branches and leaves. This is as a result of its ability to enhance water use efficiency (Kouwenhoven *et al*., 2002). The surface mulch favorably influences the soil moisture regime by controlling evaporation from the soil surface (Adekalu*et al*., 2008), and improved infiltration (Jones and Sing, 2000), soil water retention (Anikwe*et al*., 2007) and facilitates condensation of soil water at night due to temperature reversals (Tisdall*et al*., 1991).

The highest canopy diameter, number of branches, number of leaves, plant height, stem girth were recorded on rice husk mulch plots, this may be attributed to the high content of silicon and potassium of rice husk mulch which have great potential for amending soil (Ponamperuma, 1982). The use of rice straw and rice husks in the field has been practiced for some time. Research has shown that incorporation of rice straw and rice husks can significantly improve soil properties by decreasing soil bulk density, enhancing soil pH, adding organic carbon, increasing available nutrients and removing heavy metals from the system, ultimately increasing crop yields (Williams *et al.*, 1972). Similar studies on cowpea, soybean, and maize (Yamato *et al.,* 2006) have also supported the application of biochar as a way to increase crop yields. The least survival counts were recorded in rice husk mulch plots, this may be attributed to the fact that rice husk mulch used in the study formed a surface crust obstructing gaseous exchange and aeration (within and around the plant) which perhaps had negatively affected the survival of the plants. The rice husk is quite light in nature and does not support moisture retention, since it loses moisture quickly and tends to cake up easily especially when not wetted at close intervals.

Effect of different weed control methods on the yield of holy basil

Yield is the net result of various interactions viz., soil characters, weathers parameters, crop-weed completion, leaf area and various metabolic and biochemical interaction taking place during crop growth (Channappagouder*et al*., 2008). The highest yield of holy basil (578.0 g) was obtained in black polyethylene mulched plot. It was mainly due to minimum crop-weed competition throughout the crop growth period, thus enabling the crop for maximum utilization of nutrients, moisture, light and space which had influence on growth and yield components. The above results could be corroborated with the findings of Singh and Karmal (2012), Hatami*et al*. (2012) and Osadebe*et al*. (2015) who reported that higher yield in tomato and fluted pumpkin was obtained in black polyethylene mulch than other mulch materials used. Jan *et al*. (2004) reported that hand weeding treatment significantly increased the crop yield. The order of yield per hectare was black polyethylene mulch > rice husk > hoe weeding at 30 DAT > sawdust mulch > weed free > P.E spray of haloxyfop> weedy plot > white polyethylene mulch > red polyethylene mulch

CONCLUSION

From the study, it was observed that the use of mulching materials affected the growth and yield of holy basil. Covering the soil with black polyethylene mulch enhanced growth, suppressed weed and produced more yield of holy basil compared to other weed control methods. The highest yield was obtained in the black polyethylene cover due to less weed interference and therefore, the use of black polyethylene mulch is recommended for improved growth and yield of holy basil.

RECOMMENDATION

Since this crop is very important in the health and economy of the people, use of black polyethylene was able to enhance the growth, yield and also suppress weed. We therefore, recommend the use of mulch because they had higher impact in the crop yield and also the black mulch gave an appreciable growth performance and yield.

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