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Effect of different mulches on pineapple (*Ananas comosus* (L.) Merr) yield and quality traits in Southwest Ethiopia

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Abstract

Weeds affect the yield and quality of pineapple. In Ethiopia, there is insufficient scientific study on different weed management practices to improve the yield and quality of the fruit. To seal these gaps, the present study was designed to identify best mulch materials for yield and quality of pineapple in Southwest Ethiopia. Variety smooth cayenne treated with different mulch materials Soya bean straw, maize straw/stalk, black polythene/plastic, white/transparence polythene/plastic, vetiver grass, slashing/ frequent weed removal coffee husk and untreated (check) were evaluated using a randomized complete block design with three replications at Jimma, Metu and Gojeb sites. Data from weed biomass yield, fruit yield, quality traits and partial budget were collected for analyses. The result revealed that mean weed biomass and its percentage of control efficacy ranged from 1.2 kg to 7.8kg with 35.2% to 84.5%. At Jimma the maximum WCE of 86.60% with minimum WBM of 1.2kg were recorded under plot treated by black polythene. At Gojeb, plot with frequently slashed followed by black polythene treated provided the minimum weed biomass of 1k and 2.4kg with highest percentage weed control efficacy (PWCE) of 88.10 and 81.40 respectively. But at Metu, coffee husk treated plot showed the minimum weed biomass of 1.4kg next to frequently slashed plot (1.2 kg) with percent weed control efficiency of 76.30% and 79.70% respectively. However, from the overall mean result, black polythene treated plot (1.8kg) showed the minimum next to frequent slashing (1.2kg). On the other hand yield obtained under these treatment detected that, in all yield and related attributes, black polythene treated plot showed the maximum of all followed by coffee husk mulched plot. Yield of 761.20, 551.79 and 643.13 Qt/ha for polythene treated and 622.30, 463.53 and 437.31 Qt/ha for coffee husk mulched plot at Jimma, Metu and Gojeb respectively. So, since the area is coffee based farming system, there is availability of coffee husk and the farmers who can't afford the plastic polythene can use it as alternative means of mulch material.

Keywords: Mulch, Pineapple, Quality, Yield, Weed.

Introduction

Agriculture is the mainstay of livelihood and economic sources of all African countries. In order to feed the current over population, increasing the production and productivities double or triple is the only remedy. To achieve this, producers are applying fertilizers and pesticides over dosage to increase yield. However, such excess application of inorganic chemicals have negative side effects directly on soil organisms and indirectly on every living things; polluting water sources, air and soil (Ranjan *et al*., 2017).

Weeds are one among the productivity reducing factors for which chemicals applied to reduce weed effect thereby boosting productivity. It competes all sources of crops inputs and reduces quantity and quality of products. In advance of these, an increase of 1kg of weeds results in reduction of 1kg of crop growth (Abouziena and Haggag, 2016). The authors also reported that, weed scientists are now confronting other challenges like weed resistance to herbicides which result excess application of herbicide. The recent report indicated worldwide consumption of herbicides approached to 48% of 2 million tons of pesticides each year (Abouziena and Haggag, 2016). The authors portrayed also that, weed control is considered the major obstacle for the growers in the organic farming.

For the sake of reducing environmental problems and increase productivity of the crop different mechanisms have being tried by researchers. Among these mechanisms, mulch is the one which is

environmentally friendly and effective especially with the current global pollution problems. Mulch applied in production of every crops starting from nursery stage to field. Based on types of mulching materials used and purpose of application, mulching has tremendous function in soil moisture retention, weed seed and weed plant suppressing and erosion controlling mechanism. In Ethiopia the soil degradation, insect pest and different weed species problem became a serious crop yield reducing factors. So that farmers use over dose application of inorganic chemicals which resulted minimizing of pollinating agents, pollution and health problems. In southwestern part of Ethiopia such problems are practical. Perennial grasses, sedges and annual weeds with their fast and vigorous growth can affect yields and quality of the crop (Meleaku *et al.* 2015) reducing crops yield up to 90% (Spironello et al., 2004).

Although pineapple successfully grows in South and Southwestern parts at home stead and in large scale farms, the average yield of the crop is low about 45 tons/ha (IAR, 1996) as compared to global average fruit yield of 63 t/ha (Samuels *et al*., 1960). This low yield is possibly due to: lack of improved pineapple technologies for diverse environmental conditions, low weed management practices resulting low fertility status of the soil when the pineapple was grown, competing for scares resources (Hermann *et al*., 2013; Tewodros *et al*., 2018).

So, to solve such challenges, using mulches for weed management and absenting the application of hazardous chemical is possible. There are different types of mulch materials i.e biodegradable/decomposable achieved from plant parts and non-decomposable such as polythene plastics. So, to identify the appropriate and effective mulch types with cost and environmentally friendly this experiment was conducted with the objective to identify and determine the appropriate mulching materials for pineapple weed management.

Materials and Methods

Description of the study areas and Duration

Field experiment was conducted between 2017-2019 cropping seasons at Jimma Agricultural Research Center (JARC) horticultural research station, Gojeb Horizon plantation state farm and at Metu Research sub-trial site of JARC which is 265 km from Jimma. JARC which is one of the national research center found in Jimma is located 345 km far apart at southwest direction from capital city of Ethiopia and geographical description of the study areas presented below (Table 1).

Table 1. **Geographical and meteorological description of the study area summarized below**

Locations	Mean altitude (m.a.s.l)	Latitude	Longitude	Temperature (^{o}C)		Annual Rainfall (mm)
				Max	Min.	
Jimma	1753	7^{o} 40.00' N	36^{o} 47’.00’ E	26.2	12.1	1521.1
Metu	1650	8°18’ .00' N	35°35’ .00’ E	28.0	12.2	1520
Gojeb	1553	7° 3' .00' N	35° 18' .00’E	29.9	15.4	1685.9

All locations have bimodal and high rainfall natures which are suitable for the proliferation of annual and perennial weed types which compete for scarce resources.

Experimental materials, Design and arrangements

One commercially known pineapple variety i.e Smooth cayane was planted in double rows planting method with recommended spacing of 30cmx60cmx90cm intra and inter rows for the trial and different mulch materials were applied as weed controlling mechanism. The experiment was laid in randomized complete block design with three replications. The treatments used as mulches were Soya bean straw, maize straw/stalk, untreated (check), black polythene/plastic, white/transparence polythene/plastic, vetiver grass, slashing/ frequent weed removal and coffee husk. Each treatment was replicated three times.

Treatment application: These treatments were applied twice during growing seasons where the first mulch types were applied during planting and the second were after a year of the first application.

Collected data and analysis

Weed data such as biomass (kg), weed species and types were recorded using quadrate placing method of 50cmx50cm quadrate on each plot where weed types and species counted and recorded. On the other hand, pineapple data i.e plant height (cm), leaf length (cm), fruit length (cm), and fruit diameter (cm) and fruit weight (kg) were collected two rounds during growing period. Mulching was applied twice viz., the first mulching was at planting and the second was a year after planting. Collected data were analyzed using SAS ver. 9.0 software and mean separation between treatments were done using least significant difference (LSD) at 5%.

Results and discussion

Weed Types, Weed biomass and treatments weed control efficacy

The result of ANOVA for weed biomass (WBM) and treatment weed control efficiency (WCE) showed significant variation among treatments. The mean weed biomass and its percentage controlling efficacy ranged from 1.2 kg to 7.8kg with 35.2% to 84.5%. At Jimma, the maximum and minimum weed biomasses were 1.2 to 9 kg. Accordingly, the plot treated with black polythene showed the lowest WBM of 1.2kg and highest WCE 86.6% followed by plot under frequent slashing with average WBM of 1.3 kg and 85.6%. However, the maximum weed biomass and least percentage weed efficacy was recorded under control/weedy plot followed by plot treated with white polythene with the result of 9 and 5.4 kg WBM and –and 40% respectively. Additionally, in the rest locations the smallest weed biomass was recorded under plot treated with black polythene next to plot treated with frequent slashing. At Gojeb WBM of 2.4kg under black polythene and 1kg under frequent slashing with % controlling efficacy of 81.4 and 88.1% respectively. Similarly, at Metu, 1.8 kg with 70% weed efficacy under black poly next to frequent slashed plot of 1.2kg WBM with 79.70% and 1.2kg and 79.7% respectively. Totally, the combination mean results of the three locations regardless of other side effect like soil erosion, indicated efficient weed controlling mechanism achieved under plot treated with frequent slashing 1.2kg WBM with 85.4% WCE followed by black polythene treated plot with 1.8kg 79.4%WCE (Table 2.). This lowest biomass result under black poly might be due to light non-transparency habit of the plastic color and only absorb heat; so that affect weed germination percentage decreasing emergency resulting lower biomass. Contrary, the highest biomass result under white poly might be as a result of light transmission habit of the poly which hastens weed germination and growth.

Table 2. Summary of weed biomass and percentage weed control efficiency at trial sites

Treatment (mulch types)	Jimma		Gojeb		Metu		Mean	
	WBM in kg	% control efficacy	WBM in kg	% control efficacy	WBM in kg	% control efficacy	WBM in kg	% control efficacy
Soybean	3.60	60.00	7.70	8.40	3.00	50.8	4.8	39.8
Maize	4.60	49.00	5.80	31.00	4.40	25.4	4.9	35.2
Black poly	1.20	86.60	**2.40**	**81.40**	**1.80**	70.0	1.8	79.4
Vetiver grass	3.90	56.70	4.00	52.40	2.80	52.5	3.6	53.9
White poly	5.40	40.00	3.00	64.30	3.60	39.0	4.0	47.8
Coffee husk	3.00	66.70	3.00	64.30	**1.40**	76.3	2.5	69.1
Frequent slashing	1.30	85.60	**1.00**	**88.10**	**1.20**	79.7	1.2	84.5
Weedy control	9.0		8.40		5.90		7.8	
Mean	**4.00**	**63.51**	**4.41**	**55.70**	**3.01**	**56.24**	**3.83**	**58.53**

This idea was in par with the achievement of Sun *et al*., 2015 who reported that weed density and weed biomass varied with mulch color. The authors recorded the highest weed biomass and weed densities of 225.2 kg/ha with 52 weeds/m^2. In contrast, the research result of Pramanick *et al*. (2006) indicated the most effective weed management of lowest weed biomass and highest weed control efficacy were observed in blue green polythene mulch followed by black polythene mulch.

Yield and yield related traits of pineapple as affected by mulch materials

As can be seen from the Table 4 below, there was significant variation observed among treatments/mulching types in all attributes at all locations. At all locations, plot treated with black polythene showed effectively suppressed weed density thereby increasing yield and related traits. The yield obtained under this treatment in tons/ha ranged from 518.79 t/ha at Metu to 761.20t/ha at Jimma. Similarly, at Jimma and Gojeb, the greatest average weights of single fruit were achieved i.e 1.65 and 1.39kg respectively. At Gojeb it provided 643.13 t/ha (Table 4). Next to black polythene treatment, coffee husk treatment also provided the larger yield even though statistically similar with the result of most treatments.

As far as the yield and yield related attributes of pineapple in relation to treatments concerned, the highest yield were obtained at Jimma and Metu with 15.27 cm, 11.77cm and 1.64kg of fruit length, fruit diameter and fruit weight under plot treated with

black polythene followed by coffee husk treated plot at Jimma with 11.50cm of fruit length, 10.46 cm fruit diameter and 1.17 kg of fruit weight. At Metu, the highest yield and related parameters next to black poly was observed under frequent slashing with 13.20cm, 10.60cm and 1.02kg of fruit length, fruit diameter and fruit weight respectively. However, the highest yield and related traits were obtained at Gojeb under coffee husk treated plots with 15.33 cm, 11.33 cm and 1.5 kg of fruit length, fruit diameter and fruit weight respectively followed by plot treated with black poly with 12.10cm, 10.77cm and 0.89kg of fruit length, fruit diameter and fruit weight in that order (Table 4). The same result was reported by Bobby *et al.* (2017) who study effect of different color of polythene and natural mulch materials on weed control. The author reported that black-black polythene effectively controls weed density.

Table 3. Effect of different mulch materials on percentage weed index

Treatment	Yield index		
	Jimma	Gojeb	Metu
Soybean straw	55.17	55.12	26.85
Maize straw	64.26	65.74	24.42
Untreated	72.22	71.75	52.58
Black poly	0.00	0.00	0.00
Vetiver	50.47	48.03	36.26
White poly	66.83	66.08	34.03
Slashing	57.32	57.59	41.61
Coffee husk	18.25	32.00	20.36

The least the values of weed index, the higher weed controlling effect of the materials (Bobby et al., 2017). From the result Table 4, the least percentage weed index was obtained from mulch material of black poly followed by coffee husk at all location. Mulching by coffee husk was recorded the least of 18.25%, 32.00% and 20.36% at Jimma, Gojeb and Metu next to black polythene treated plot (0%) respectively (Table 3). So, since the area is coffee based farming system, there is available coffee husk, the farmers who can't afford the plastic polythene can use it as alternative means of mulching material.

Table 4. Effect of polyethylene mulches on physico-chemical composition of pineapple variety smooth cayenne.

No	Treatment type	Moisture Content %	Dry Matter Content	TA	pH	TSS
1	Soya bean straw	82.3	17.7	0.02	3.73	14.1
2	Maize	88.5	11.5	0.019	3.74	14.7
3	Check	83.55	16.45	0.02	3.58	15.1
4	Black poly	87.8	12.2	0.03	3.63	13.2
5	Vetiver grass	82.3	17.7	0.019	3.57	15.0
6	White poly	85.45	14.55	0.02	3.95	12.2
7	Slashed	88.85	12.15	0.016	3.44	12.6
8	Coffee husk	84.9	15.1	0.022	3.50	13.1
	Mean	85.46	14.67	0.02	3.64	13.75

The effect of polyethylene mulches on physico-chemical composition of pineapple variety smooth cayenne was presented in Table 5. The result revealed that mean fruit moisture contents ranged from 82.30 to 88.85% with a mean of 85.46%. The ranges of dry matter (11.50 to 17.70%), titratable acidity (0.02 to 0.03), pH (3.44 to 3.95) and TSS (12.2 to 15.10). The variability among mulches on pineapple variety smooth cayenne in respect to different physico chemical character revealed wide chance to improve pineapple yield possessing desirable quality traits.

Table 5. Mean fruit yield and related traits of pineapple in tested locations as affected by different mulch types

Treatments	Jimma				Metu				Gojeb			
	FL (cm)	FD (cm)	FWt (kg)	Yield (Qt/ha)	FL (cm)	FD (cm)	FWt (kg)	Yield (Qt/ha)	FL (cm)	FD (cm)	FWt (kg)	FW (Qt/ha)
Soybean straw	10.62^{bc}	9.21^{b}	0.68^{cd}	314.24^{cd}	11.33^{b}	10.55^{ab}	0.78^{d}	425.58^{bc}	11.67^{ab}	10.88^{b}	0.63^{cd}	288.62^{cd}
Maize straw	9.57^{c}	8.75^{b}	0.58^{de}	272.00^{de}	11.50^{b}	9.95^{ab}	0.73^{d}	439.66^{b}	9.33^{e}	9.03^{cd}	0.48^{de}	220.29^{de}
Black poly	**15.20^{a}**	**12.48^{a}**	**1.65^{a}**	**761.20^{a}**	**13.90^{a}**	**11.45^{a}**	**1.26^{a}**	**581.79^{a}**	**15.07^{a}**	**12.70^{a}**	**1.39^{a}**	**643.13^{a}**
Vetiver	10.90^{b}	9.51^{bc}	0.83^{c}	377.00^{c}	11.17^{b}	9.72^{ab}	0.92^{c}	370.83^{bc}	11.00^{bcd}	9.81^{bcd}	0.72^{c}	334.18^{c}
White poly	9.99^{bc}	8.90^{b}	0.54^{de}	252.48^{de}	10.74^{b}	9.18^{ab}	0.66^{e}	383.77^{bc}	11.74^{bc}	9.38^{cd}	0.47^{de}	218.13^{de}
Slashing	10.27^{bc}	9.48^{b}	0.71^{cd}	324.85^{cd}	11.40^{b}	10.60^{ab}	1.02^{b}	339.70^{cd}	10.73^{cde}	9.55^{cd}	0.59^{cd}	272.69^{cd}
Coffee husk	**11.10^{b}**	**9.99^{b}**	**1.17^{b}**	**622.30^{b}**	**11.51^{b}**	**9.89^{ab}**	**1.05^{b}**	**463.35^{b}**	**11.23^{bcd}**	**9.94^{bc}**	**0.95^{b}**	**437.31^{b}**
Untreated	10.15^{bc}	8.75^{b}	0.46^{e}	211.42^{e}	9.97^{c}	8.48^{b}	0.56^{f}	275.85	9.80de	8.65^{d}	0.3^{e}	181.67^{e}
Mean	10.98	9.63	0.84	391.94	11.44	9.99	0.89	410.06	11.43	9.99	0.70	324.50
CV	10.18	11.27	18.75	18.73	8.33	9.07	19.32	19.32	11.79	10.23	5.18	23.82
LSD (5%)	1.31	1.27	0.18	85.84	1.11	1.28	0.20	92.59	1.57	1.19	0.19	90.34

FL=fruit length, FD=fruit diameter, FWt=fruit weight

Conclusion

Weeds highly compete pineapple for scarce resources under no management reducing yields in significant amount. To reduce this competition thereby enhancing yield of pineapple, different weed management mechanisms were studied. Among these treatments, black poly was found to be the best mulch material for suppressing weed seed emergency, while white poly poor mulch material for weed control because of the fact that it allows light which is one of the important factors for weed germination and growth. The current finding also showed that coffee husk was also good mulch material for weed control in pineapple.

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