Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.6, 2014

Effect of Mulch Type, Ground Cover Percentage and Sucker Management on Growth and Yield of Pineapple *(Ananas Comosus* L. Merrill) under Growing Conditions of Sidama Zone, Southern Ethiopia

Daniel Markos (Corresponding author)
Awassa Agricultural Research Center, P.O.Box-06, Awassa, Ethiopia; tEl:
E-Mail:danielmarkos2012@gmail.com

The research is financed by Southern Agricultural Research Institute, SARI.

Abstract
A study was carried out in Nitisols of Makala, Aleta chuko district of Sidama Zone from 2006 to 2010 with the objective of identifying optimum number of suckers, mulch types and amount of mulch that produce optimum fruit yield of pineapple. The treatments consisted of mulch type (vetiver vis coffee husk), ground cover percentage (GCP) (0, 50, 75, 100 and 125% of ground cover) and sucker management (one, two, three, four, intact). Results showed that sucker management ($p<0.01$), mulching the ground and their interaction ($p<0.05$) produced significantly greater fruit numbers and higher pineapple fruit yield at Makala. 0.99 to 1.06 values of crown length to fruit length ratio obtained due to the imposed management showed that quality fruits could be obtained due to 75 – 100 GCP and managing suckers. However, the two way interaction effects of sucker regulation and mulching resulted in significantly ($p<0.05$) higher fruit yield per unit area. Among the mulch types compared, coffee husk produced significantly ($p<0.05$) greater fruit yield compared to vetiver mulches (mainly meant for weed suppression). This study depicted that use of coffee husk at the rate of 100% ground cover percentage while retaining two suckers per stand would maximize the growth and yield components of pineapple.
Key words: Mulch type, ground cover percentage, sucker management, fruit yield

1. Introduction

Pineapple (*Ananas comosus* L. Merrill) is one of the leading tropical fruits in international commerce. Biologically, it is a perennial herb and it belongs to the family *Bromediaceae*. It is xerophytic crop undergoing Crassulacean acid metabolism (CAM), which is characterized by carbon dioxide absorption in the night, conversion of this carbon dioxide in to acids (mallic and citric) in those times and there by closing their stomata during the day to limit water use. The plant is very drought resistant but the root system is shallow so that under dry conditions growth stagnates quickly. A fruit from low lands is larger, sweeter and juicier than fruits grown from mid lands. Pineapples are cultivated for their mature ripe fruits for local consumption, flesh and juice for canning and export (Samson, 1980).

Pineapple cultivars show considerable variation in their plant growth and fruit size when grown in different environments (Nakasone and Paull, 1998). Drainage should be perfect because waterlogged plants quickly succumb to root rot and growth stagnates where moisture is lacking. Therefore, a growing technique shall allow weed suppression, moderate moisture levels and excellent drainage. To meet this requirement, some growers use black polyethylene strips and plant through it. In Ethiopia also mulching has been recommended in rift valley soils to increase water retention and reduce run off as these soils are shallow, compact and frequently had surface crusting (IAR, 1990). Mulching with weeds up rooted during cultivation has been a traditional soil and water conservation technique that improves yield mainly due to improvement of soil microclimate, enhancement of soil life, structure and fertility, conserve soil moisture, reduce weed growth, prevent damage of solar radiation and rain fall, and reduce the need for frequent tillage (Reijntjes et al., 1992). Various authors indicated that there is sufficient coffee husk by product in wet and dry coffee processing sites of the country (Tsige, 1989; Finney, 1990; Tsige and Steinbach, 1996).

Pineapple prefers sandy loam soils of low water retention capacity, grows in places of relatively more sunshine and higher temperature and susceptible to weeds since early stage of growth. However, frequent cultivation with hoe increases the probability on inserting soil into pineapple leaves there by stagnating growth. Hence, mulching with locally available materials is of paramount significance. Nakasone and Paull (1998) reported that crown increases about 30-45 days after fruit growth has commenced and hence crown growth removed early in fruiting leads to greater fruit weight. In another report growers in Malaysia, for example, removed some slips

from bottom of the fruit and also the crown from the plant when it is about 5-8 cm long mainly because these growth components compete with the fruit growth. In Malaysia, low yields are generally due to wide spacing, plant losses, reduced growth rates and inadequate flower inductions. Particularly when pineapple is grown for the fresh fruit market like in most places of Ethiopia, removing the crown (leaving the peduncle) is vital if not possible to reduce it by cutting the meristematic tissues of the crown with a sharp implement (which is called gouging) (Samson, 1980; Malo and Campbell, 1994). In Hawaii, gouging was recommended just two months before harvest to limit crown growth and avoid visible scaring. Moreover, crown size to fruit length was also used as fresh fruit quality standards where the optimum is 1.00 to 1.5 (Nakasone and Paull, 1998). However, gouging treatments varies with cultivars grown, environmental conditions like humidity, rainfall and temperature in a given area and hence require a close much with local growing conditions.

Pineapple fields in Thailand produce two crops, the plant crop plus a single ratoon crop from one sucker left there by since the beginning (Malo and Campbell, 1994; Nakasone and Paull, 1998). Research work at Gojeb and Bako identified suckers as best planting materials with respect to yield, maturity date and fruit quality. The findings of Bako indicated that the yield was low and harvesting was delayed when slips planted. Plants propagated from sucker came to bearing earlier than slips and crowns. At Gojeb suckers and slips started fruiting earlier than the crowns. The slips were more uniform and vigorous than the other two types of planting materials. Farmers' experience in some pineapple growing areas of Southern region indicated variable practice of sucker management. In particular, the number of suckers planted during the beginning of growing season and the number of suckers maintained thereafter in the field where different in different fields within the same growing environment. For instance farmers at *Makala* traditionally use to plant 5 to 7 suckers/hill as opposed to those that plant a single sucker and also there are farmers that leave a single suckers. Leaving suckers intact was beneficial for better weed control, demands less frequent cultivation and leads to earlier maturation, but renders difficulty to manage the field, produces inferior sized fruits and the plant stays in the field for over seven years. However, it was not yet established via research how much of these suckers were profitable to smooth cayenne variety for the growing conditions of the farmers. Therefore this experiment was carried out with the objective of identifying optimum number of suckers, appropriate mulch type and ground cover percentages that produce optimum economic fruit yield of pineapple.

2. Materials and methods

The experiment was carried out in *fluvisols* of Makala (Chuko woreda of Sidama Zone) of SNNPR from 2007 to 2010 in order to identify suitable mulching materials, ground cover percentages also called mulching rates of the identified materials and determine the number of suckers to be retained with mother pineapple. The treatments included five levels of mulching (0% ground cover *i.e* 0 t/ha, 50% ground cover i.e 41.2t/ha , 75% ground cover *i.e* 61.8 t/ha, 100 % ground cover *i.e* 82.4 t/ha and 125 % ground cover *i.e* 103t/ha), five levels of sucker management (1, 2, 3, 4 and intact suckers) and mulching materials (coffee husk and vetiver mulch). The design was set in RCBD with factorial arrangement with three replications. The mulch was gradually applied thrice (at planting, after sixth month and in 12th month after planting) each time until it covered the ground to the desired percentage and later the amount was recorded for comparison. The recommended spacing of (90 + 60) cm x 30 cm means that planting was done in double rows where the path was 90 cm wide, the two rows in a pair 60 cm apart and the plants in each row 30 cm apart, giving a density of 4.4 plants/m^2 with a variety called S*mooth cayenne*. Data were collected on crown length, fruit number, weed count and weed biomass yield, length and diameter of fruit, weight of fruit per plot, and crown length to fruit length ratio. Results were analyzed using ANOVA appropriate for 2 x 5 x 5 factorial combinations.

3. Result and discussions

3.1 Main effects of mulch types, mulch rates and sucker management on growth and yield of pineapples

Ground cover percentage (mulch rate) significantly affected fruit number ($P<0.01$), fruit diameter ($P<0.05$), crown length ($p<0.001$) and fruit yield ($P<0.01$) where as the effect of sucker management was significant in fruit number ($P<0.01$), crown length ($p<0.05$), fruit length ($P<0.05$), fruit diameter ($P<0.01$) and fruit yield ($P<0.01$) of pineapple (Table 1).

The effect of GCP averaged over sucker management was significant on fruit number/ha ($p<0.01$), crown length ($p<0.01$) and crown length/fruit length ratio. However, the main effect of GCP was not significant on fruit length and fruit diameter. The main effect of sucker management averaged over GCP was significant on all traits measured in the field (Table 2). Results indicated that crown length and crown length/fruit length ratio decreased as GCP was increased where as fruit number/ha and fruit yield/ha was increased as GCP was increased. The effect of sucker management revealed that growth and yield components increased as the number of suckers retained was increased until two to three suckers; however, the triats showed decreasing trend as the mother plants started to retain more than three suckers in a hill/stand. Consequently, significantly higher fruit number/ha

(p<0.01) (81939) was counted due to three suckers retained in a hill compared to other levels of suckers retained. Conversely the fruit number/ha counted due to one sucker retained/hill was 70384.62, which was significantly lower (p<0.01) compared to other levels of sucker retained.

Fruits were significantly larger (p<0.01) due to one sucker retained with the mother plant compared to retaining two or more suckers in a hill. In fact, retaining two suckers with mother plant has also resulted in invariable result to that of retaining one sucker as far as fruit diameter was concerned. Significantly lower fruit diameter was due to intact sucker management where as no sucker regulation was carried out compared to sucker regulation. The effect of GCP on crown length/fruit length ratio showed that significantly higher (p <0.01) due to 75 – 100 GCP compared to other ground cover percentages. Similarly the variation of crown length to fruit length ratio was significantly higher due to retaining one to four suckers/hill compared to intact suckers. Fruit yield/ha was significantly lower (p<0.01) due to retaining single sucker with mother plant compared to other sucker retaining levels. In fact, fruit yield/ha were significantly higher and invariable due to retaining two, three or four suckers compared to retaining one sucker (Table 2).

3.2 Interaction effects of mulch types, mulch rates and sucker management on growth and yield of pineapples

The GCP by sucker management interaction effects were significant on fruit number (P<0.05), fruit length (P<0.01), fruit diameter (P<0.001), crown length (P<0.01), and fruit yield (P<0.05) (Table 1). At zero GCP or unmulched plots, the number and dry weight of weeds was invariable As GCP was increased, weed quantity and biomass decreased rampantly. Significantly higher (p<0.05) weed number was recorded due to zero GCP or unmulched plots compared to covered or mulched soils. Conversely, the weed quantity and weed dry matter was significantly lower due to 100 to 125 GCP compared to unmulched barren soils or lower GCP levels. The fruit yield was significantly higher (p<0.05) due to 75 to 100 GCP of coffee husk mulch compared to other levels of coffee husk and vetiver mulch (Table 3). This could be attributed to hindrance of light transfer to the emerging weed seed. As Kang *et al*.(1976) rightly indicated weeds showed higher percentage of N, P, K, Ca, and Mn than most heavy feeder crops. The weeds also removed substantial amounts of N and particularly K and Mg.

Fruit number/ha responded significantly (p<0.05) to two way interaction effect of GCP and sucker regulation (Table 4). Results showed that greater than 82,000 fruits could be harvested in a hectare of land when GCP is 100 and suckers are two per hill or stand or mother plant, GCP is 50 to 75 and suckers are three/hill or GCP is 0 to 50 and suckers are four or more with the mother plant. The lowest fruit number/ha was recorded in zero level of GCP/unmulched/barren fields where the number of suckers retained with mother plant is only one.

Fruit yield/ha was significantly higher (p<0.05) due to 75GCP and four suckers/hill, and 100 –125 GCP and two suckers/hill compared to other interaction levels (Table 5). Conversely, fruit yield/ha was significantly lower due to one sucker retained with mother plant regardless of the ground cover percentage in the pineapple stand. The maximum fruit yield obtained in the experiment (83.5t/ha) was obtained due to four suckers retained with mother sucker under 75 GCP. In fact, 79 to 81 t/ha fruit yield obtained due to 100-125GCP in plots with two suckers is indifferent and invariable statistically. This was because of the fact that the extra suckers retained with mother plant did suppress the growing weed by shadowing and competing the resources. Moreover, the fields are unmanageable if mother plants are left with three or more suckers as optimization of resource use and scheduling harvesting get complicated. Conversely the plots with fewer suckers are manageable during weeding and picking the fruits compared to intact or four suckers. Therefore, it is advisable to use two suckers with 100-125GCP of locally available mulch like that of coffee husk.

3.3 Association of characters

There was strong and positive relation index among fruit number and pineapple fruit yield (R^2=0.866, P<0.001). Similarly, the association index was significant and positive among fruit length and fruit diameter (R^2=0.808, P<0.001). This means that fruit number and diameter are dominant triats that determine fruit yield of pineapple in the study area. The result manifested that plants with more number of large sized fruits produced greater yields, and large sized fruits are more likely that they become taller too. Contrarily, negative association was observed among crown length and fruit length, fruit diameter and ultimately fruit yield. Thus, crowns are longer in smaller or under sized fruits and conversely large sized fruits usually have smaller crowns in pineapple *var. smooth cayenne.*

4. Conclusion and recommendations

The magnitude of effect of each treatment depicted that sucker regulation, and interaction of sucker management with GCP has resulted on magnificent effect on fruit length and diameter unlike the GCP employed in the study. The primary benefit of covering the pineapple field was to hamper the performance of bank of weed seeds besides soil temperature optimization and nutrient enrichment. As this study revealed, plots that were managed by leaving two suckers and mulching with 100-125GCP of coffee husk produced agronomically superior yield.

As the number of suckers retained with mother sucker was increased, fruit diameter has decreased; but fruit length has increased. Results showed that higher pineapple growth and yield components were recorded due to two suckers retained per hill. This is against the traditional cultural practice of retaining any sucker growing with mother plant. The optimum combination of the required fruit size was judged by the combination of these two traits with that of individual fruit weight. The desired fruit size shall have higher fruit length to crown length ratio (1.0 to 1.5), larger fruit diameter and longer fruit length. 0.99 to 1.06 values of crown length to fruit length ratio obtained due to the imposed management showed that quality fruits could be obtained due to 75 – 125 GCP and managing suckers. If GCP is 100% and above, then two suckers left per plant would provide quantitatively equal amount of fruit yield with that of four suckers left in GCP of 50 to 75% of ground cover. However, the CL/FL ratio showed lower values for unmulched plots with more suckers compared to mulched plots with fewer suckers. This might be due to lack of sufficient plant nutrition to assist the fruits beared by all suckers which otherwise could have been supplemented by coffee husk in mulched plots. In fact, the fields with two suckers are quiet manageable during weeding and picking the fruits compared to intact or four suckers. Therefore, it is advisable to use two suckers with 100-125GCP of locally available mulch like that of coffee husk.

5. References

Finney, A. 1990. The Technology of processing, “Fully washed” Arabica coffee. African Coffee 25: 6-13

IAR. 1990. 21st National crop Improvement Conference. Proceedings of IAR from 10-12 April 1989. Addis Ababa,Ethiopia.

Malo, S.E and C.W. Campbell. 1994. THE PINEAPPLE, Florida Cooperative extension service, University of Florida, Fact sheet HS-7

Nakasone, H. Y. and R. E. Paull. 1998. Tropical Fruits, CAB International, Biddles Ltd., Kings Lynn, United Kingdom.

Reijntjes, C., B. Haverkort and A. Waters-Bayer. 1992. Farming for the Future: An international to low external input sustainable Agriculture, Macmillan-ILEIA, Leusden, The Netherlands. Samson, J.A. 1980. Tropical Fruits. Pp. 162-183.

Tsige-Yohanes Habte and Steinbach, J. 1996. The chemical composition and source of variation of coffee pulp. Ethiopian J. Agric. 15: 113-120.

Tsige-Yohanes Habte. 1989. Investigation on the Nutritional Value of Coffee Pulp. Ph.D Thesis, University of Giessen, Germany.

Kang, T., F. Donkoh and K. Moody (1976) Soil Fertility Management Investigations on Benchmark Soils in the Humid Low Altitude Tropics of West Africa: Investigations on *Egbeda* Soil Series, Agronomy Journal Vol. 69 No. 4, p. 651-656

Table 1. Mean squares of growth and yield components of pineapple *var. smooth cayenne*

Source of error	Fruit number	Fruit length	Fruit diameter	Fruit yield	Crown length
Replication	16.21ns	14.65**	2.27**	43.3ns	3.243ns
Ground cover percentage(GCP)	83.68**	0.67ns	0.96*	134.32**	8.78***
Sucker management (SM)	108.45**	1.35*	1.98**	109.83**	6.60*
GCP X SM	43.46*	1.48**	1.61***	54.66*	3.79*
Error	21.92	0.50	0.39	25.21	2.16
CV (%)	**13.68**	**6.02**	**6.84**	**16.13**	**10.64**

*, **, *** refer to significance at 5 and 1, 0.1% of probability; ns stands for absence of significant difference at 5% level of probability

Table 2. Effect of sucker management and GCP on growth and fruit yield of pineapple *var Smooth cayenne*

Traits	Fruit number/ha	Fruit yield (t/ha)	Fruit length (cm)	Fruit diameter(cm)	Crown length(cm)	Crown length /fruit length ratio
GCP,%						
0 GCP	68754.78	55.00	13.81	11.29	13.1	0.95
50 GCP	75732.56	62.12	13.96	11.87	13.3	0.95
75 GCP	76577.02	71.10	14.14	11.28	15.0	1.06
100 GCP	81806.72	70.32	14.21	11.27	14.1	0.99
125 GC P	77347.66	69.16	14.35	11.29	13.5	0.94
LSD	2686.4**	8.02**	NS	N S	1.05**	0.091**
Sucker management, no.						
ONS	70384.62	56.56	13.78	11.87	13.60	0.99
TWS	72754.82	66.10	13.92	11.56	13.83	0.99
THS	81939.98	68.12	14.43	11.38	14.40	1.00
Sucker management						
FOS	78399.20	72.42	14.15	11.34	14.40	1.05
INS	76740.12	64.50	14.59	10.85	12.80	0.88
LSD	2686.4**	8.02**	0.76*	0.42**	0.95*	0.091**
CV (%)	13.68	16.13	5.03	5.46	10.64	10.71

GCP= ground cover percentages, ONS=one sucker/hill, TWS=two sucker/hill, THS=three sucker/hill, FOS=four sucker/hill, INS=intact suckers, *, ** refer to significance at 5 and 1% of probability; NS stands for absence of significant difference at 5% level of probability

Table 3. Combined effect of mulch type and GCP on fruit yield (t/ha) of pineapple *var. smooth cayenne*, weed dry weight (t/ha) and weed number

Ground cover percentage	**Fruit yield (t/ha)**		**Weed dry weight (t/ha)**		**Weed number**	
	Vetiver mulch	**Coffee husk**	**Vetiver mulch**	**Coffee husk**	**Vetiver mulch**	**Coffee husk**
0 % GCP	38.9	*48.8*	96.1	96.0	4661287	4527954
50 % GCP	45.2	70.7	97.8	94.0	4219957	3695963
75 % GCP	53.2	82.4	72.6	85.2	3797739	3471965
100 % GCP	51.2	85.5	55.9	71.2	4119958	2991081
125 % GCP	58.9	68.8	56.1	67.9	3756406	2959970
$LSD_{5\%}$	**9.20**		**15.80**		**787769**	

GCP= ground cover percentages, NS stands for absence of significant difference at 5% level of probability

Table 4. Effect of sucker management x mulching rate on fruit number (no/ha) of pineapple *var. smooth cayenne*

Sucker management	**Ground cover percentages (GCP)**				
	O%GCP	**5O%GCP**	**75%GCP**	**10O%GCP**	**125%GCP**
ONS	48888.4	65999.3	79999.2	79999.2	77037.0
TWS	51110.6	75554.8	76221.5	83776.9	77110.3
THS	73332.2	83776.9	88888.0	88148.0	75554.8
FOS	88221.3	84443.6	68888.2	74888.1	75554.8
INS	82221.4	68888.2	68888.2	82221.4	81481.4
			SM X GCP		
		LSD	**6007.1***		
		CV (%)	**13.68**		

GCP= ground cover percentages, ONS=one sucker/hill, TWS=two sucker/hill, THS=three sucker/hill, FOS=four sucker/hill, INS=intact suckers, * refer to significance at 5 % of probability

Table 5. Effect of sucker management x mulching rate on yield (t/ha) of pineapple *var. smooth cayenne*

Sucker management	**Ground cover percentages (GCP)**				
	O%GCP	**5O%GCP**	**75%GCP**	**10O%GCP**	**125%GCP**
ONS	49.3	49.5	63.3	64.2	56.5
TWS	51.5	52.2	66.7	79.2	80.9
THS	62.7	66.2	70.4	66.9	74.4
FOS	72.2	72.1	83.5	69.6	64.7
INS	39.3	70.6	71.6	71.7	69.3
			SM X GCP		
		LSD	**8.33****		
		CV (%)	**16.13**		

GCP= ground cover percentages, ONS=one sucker/hill, TWS=two sucker/hill, THS=three sucker/hill, FOS=four sucker/hill, INS=intact suckers, ** refer to significance at 1% of probability

Table 6. Coefficient of correlation (R^2) among growth and yield components of pineapple var. *Smooth cayenne* (N=75)

Traits	**Fruit number**	**Fruit length**	**Fruit diameter**	**Crown length**	**Fruit yield**
Fruit number	1.00				
Fruit length	0.285*	1.00			
Fruit diameter	0.038ns	0.808**	1.00		
Crown length	-0.284**	-0.082ns	-0.169*	1.00	
Fruit yield	0.866***	-0.041ns	0.103ns	-0.314**	1.00

*, **, *** refer to significance at 5 and 1, 0.1%; NS stands for absence of significant difference at 5% level of probability