Impact of Mulching on Soil Moisture, Plant Growth and Yield of Mauritius Pineapple (*Ananas comosus.* L. Merr)

A Janaki Alwis and HKMSK Herath

ABSTRACT

The impact of mulching on soil moisture and pineapple (*Ananas comosus.* L. Merr) growth and yield was studied from 2003-2005 at Makandura Research and Development Center. Soil moisture content at 30cm depth was significantly different among treatments at the harvesting stage. Highest soil moisture content of 10.9 at 30cm depth at harvesting was recorded in the coir dust mulch was not different from soil mulching (soil mounding), black polythene, and paddy husk treatments. There was no difference in moisture content at 15cm depth between all treatments at tested growth stages. Highest D-leaf length of 92.1cm recorded in the coir dust mulch treatment was not different from sawdust, paddy husk, black polyethylene, and soil mulching treatments in both seasons. The highest fruit yield of 24.3t/ha in the plant crop was recorded in the black polythene treatment. It was significantly higher than the poultry litter, coconut husk, paddy husk, and rice straw treatments. Similar trend in the yield was observed in the second season. Therefore, it can be concluded that the impact of coir dust, soil mulch (soil mounding), black polythene, and sawdust treatments had shown similar impact on soil moisture, plant characters and fruit yield. During on- farm demonstrations, because of minimum expense and convenience growers appreciated soil mulching as the best substitute for coir dust mulching.

Key words: Mounding, Mulching, Pineapple, Soil moisture.

INTRODUCTION

Pineapple (*Ananas comosus* L. Merr) cultivation has been intense in the wet zone and in the intermediate zone under rain fed condition because of agro-ecological reasons and socio-economic reasons (DOA, 1999). For the most part, this area overlaps with the coconut triangle. Despite the fact that supplementary irrigation has been introduced into pineapple to expand the cultivation in drier areas, the majority of the crop is still being managed under rain fed conditions.

Soil moisture is the most important natural resource in the rain fed agriculture. Therefore, successful cultivation of rainfed pineapple depends on the skillful management of soil moisture through proper moisture conservation techniques. Even if irrigation is expanded, due to the scarcity of irrigation water in the potential pineapple growing areas (Amarasinghe et al., 1999) skillful management of soil moisture is essential. Since mulching reduces the soil moisture evaporation significantly (Klocke, 2004), it has been extensively used in pineapple cultivation.

Traditionally coir dust has been used as a mulch to reduce evaporation and the water stress in plants, lower soil temperatures around plant roots, prevent erosion and reduce weed growth in pineapple plantations. However, with the expansion of the coir dust export industry traditionally used coir dust has become expensive and scarce for the pineapple cultivation even in the coconut triangle. Therefore, a field experiment was conducted on an alluvial soil (deposit over red yellow podzolic) in the Kurunagela district from 2003 to 2005 to identify an alternate mulching material for rainfed pineapple cultivation.

MATERIALS AND METHODS

Field Establishment

Healthy auxiliary suckers each containing 15 leaves were collected from a well-maintained mauritius pineapple (*Ananas comosus.* L. Merr) plantation and were treated using profenofos and benomil for pests and diseases. Treated suckers were planted in single rows in the field at Makandura Research Centre (30 cm within row and 2m between rows- 14,600 plants/ ha) in November 2003.

Regional Agriculture Research and Development Centre,
Makandura, Gonawila(NWP).

Treatments and Management

Eight mulching materials were assigned according to the Table 1 as the treatments. Since there is inadequate information available on the rate of application of tested mulching materials, the rate of application for the study was calculated based on the long-standing coir dust mulching practice. The long standing practice is 20cm elevated mound (ridge) of fresh coir dust for 60cm width on either side of the plant row. One month after planting with the application of the first topdressing mulching treatments were applied. Except for mulching treatments all cultural practices were carried out according to the recommendations of the Department of Agriculture. The crop was maintained for two consecutive seasons (plant crop and ratoon crop) under rain fed conditions.

Table 1: Mulching treatments applied to Mauritius pineapple

Treatments	Description
T1-	Fresh cut, air dried rice straw 20cm mound of 60 cm width in each side
T2-	Fresh saw dust 20cm mound of 60 cm width in each side
T3-	Fresh paddy husk 20cm mound of 60 cm width in each side
T4-	Fresh coconut husk 20cm mound of 60 cm width in each side
T5-	Black polythene –800 gauge, single layer of 60 cm width in each side
T6-	Soil mulching 20cm mound of 60 cm width in each side
T7-	Control; fresh coir dust 20cm mound of 60 cm width in each side
T8-	Fresh poultry litter 20cm mound of 60 cm width in each side

Soil mulching (mounding) is different to the conventionally used earthing-up in agriculture. Earthing-up is a technique where the soil surrounding a plant is placed against the main stem to prevent light from affecting a crop (root and tubers).

With mulching, it is ensured that the "heart" of the pineapple plant is not buried in the mulch to prevent rotting. The mound was formed as a ridge away from the plant base and the highest point of the mount (20cm elevation) was in the middle of the 60cm wide ridge. Thus, the highest point of the mound was 30cm away from the pineapple plant base.

Environmental Conditions

Experiment was conducted at the Agriculture Research Centre, Makandura (7^0 20' N, 80^0 00' E) that is located in the North Western Province. Makandura falls within the low country intermediate zone (IL_1), agro-ecological region. Table 2 presents mean of the environmental conditions that prevailed during the last ten years (from 1994-2004).

Measurements

Soil moisture content at 15cm and 30cm depths was measured gravimetrically at three months and six months after planting and at the harvesting stage. Soil temperatures at 15cm depth at 8.00am and at 2.00pm were measured in three months and in six months after planting using soil thermometers. Plant growth parameters namely D-leaf (Strong, longest and healthy leaf of the plant) length and width, number of leaves per plant, stem length and girth were recorded at the red bud stage. Subsequently, fruit yield and fruit quality parameters namely fruit length and girth were recorded.

Statistical Design

A Randomized Complete Block Design (RCBD) with three replicates was used in the experiment. Data were analyzed using ANOVA via the SAS package 6.12.

RESULTS AND DISCUSSION

Leaf Parameters

Analysis of D-leaf is used to estimate plant growth, as it is the only leaf that can easily be identified and provides a reliable and sensitive indication of

Table 2 - Environmental conditions at Makandura (ten-year average 1994 to 2004)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max.air Temp (C^0)	32	34	35	34	33	31	31	31	31	31	32	32
Min.air Temp (C^0)	22	22	22	24	25	24	24	24	24	23	23	22
Total Rf (mm)	66	76	42	243	246	123	107	101	224	347	293	118
Pan Evap (mm/day)	4	5	5	4	4	4	4	4	4	4	3	3
Wind velocity (km.p.h)	4	3	3	3	4	5	5	5	4	3	2	3
R.H.%-M	83	80	78	79	83	83	82	82	83	84	84	82
R.H.%-E	63	57	58	67	73	75	74	72	73	77	76	69

Source : RARDC, Makandura

pineapple plant growth (Sideris and Krauss, 1936). In the first season, D-leaf length was significantly different among the mulching treatments but not different with Saw dust, Paddy husk, Black polythene, Soil mulching and coir dust. (Table 3) but treatments had no significant effect on its width. Coir dust treatment had the longest D-leaf in the plant crop and it did not differ from sawdust, paddy husk, black polythene and soil mulching treatments. Thus the estimated plant growth in the coir dust treatment was not different from plants in the sawdust, paddy husk, black polythene and soil mulching treatments. In the ratoon crop there was no difference in the d-leaf length among treatments but the width was significantly different among treatments. These findings are in agreement with Chaudhry et al., (2004) who reported that mulching treatments had some positive impact on plant growth, but the intensity of the effect can be different with different treatments.

Stem Parameters

Evaporation of soil water is a major component of the crop water balance. Most crops have incomplete cover throughout a significant part of a growing season and do not contribute significantly to moisture conservation. Early development of a pineapple canopy cover is therefore an advantage. Fully-grown pineapple plant canopies effectively suspend water vapor exchange and minimize water uptake as well as evaporation from the soil surface. Pineapple stem length is an important factor to explain the plant canopy structure and any effect on stem

Length directly influences the soil moisture conservation (Ekern, 1962). Tested mulching treatments had a significant effect (Table 4) on the stem length and stem girth of pineapple plants. In the plant crop (first crop), both stem length and stem girth of plants in the coir dust treatment were different from poultry litter treatment, but not from the other treatments. In the ratoon crop stem length showed a higher variability than in the plant crop. These findings are in agreement with Chaudhry et al., (2004) who reported that all the mulching treatments had some positive impact on plant growth parameters but it varied with different mulching treatments. Further, these findings are in agreement with Stewart (2005) who reported that plant height was positively affected by moisture conservation through the use of soil mounding in grape vine.

Yield Parameters

In pineapple, economic yield (fruit yield) is the most important factor. In this study, the mulching treatments had a significantly effect (Table 5) on the fruit yield. Depending on treatments fruit yield

Table 3 - Leaf parameter prior to flower induction.

Treatment	DL cm PC	DW cm PC	No leaves PC	DL cm RC	DW cm RC	No leaves RC
Rice straw	84.4	5.9	49	72.6	4.6	45
Saw dust	87.4	5.6	49	75.2	5.3	55
Paddy husk	86.7	5.8	50	78.3	5.0	53
Coconut husk	83.4	5.2	45	71.1	4.6	49
Black polythene	86.3	5.1	54	70.1	5.1	52
Soil mulching	86.9	5.4	50	71.1	4.5	54
Control – Fresh Coir dust	92.1	5.9	54	82.2	4.9	52
Poultry litter	71.7	5.3	58	65.0	4.6	49
Pr>F	***	Ns	*	ns	*	ns
LSD	6.9	-	6	-	0.5	-

DL – D-leaf length, DW- D-leaf width, PC – plant crop, RC- ratoon crop. ***Significant at the 0.001 level of probability. ns- Not significant at the 0.05 level of probability.

Table 4 - Stem parameters at redbud stage.

Treatment	Stem length cm plant crop	Stem girth cm plant crop	Stem length cm ratoon crop	Stem girth cm ratoon crop
Rice straw	21.8	16.7	23.2	16.7
Saw dust	20.3	16.3	24.3	17.7
Paddy husk	21.2	16.4	20.8	16.8
Coconut husk	19.7	16.2	18.0	17.3
Black polythene	22.3	16.0	24.7	18.3
Soil mulching	21.0	16.0	21.0	17.2
Control – Fresh Coir dust	21.5	16.3	24.8	17.8
Poultry litter	25.5	18.8	21.3	16.3
Pr>F	**	*	**	Ns
LSD	2.4	1.7	3.2	-

* *Significant at the 0.01 level of probability.

varied from 19.4 to 24.3 tons/ha in the plant crop demonstrating the variability in cropping conditions. Black polythene, soil mulching, coir dust, and saw dust had similar yields in the plant crop. Similar trend in yield was observed in the ratoon crop.

In both seasons, fruit length did not change significantly with the tested treatments. However, fruit girth (fruit filling) in the plant crop showed a significant difference among treatments and the trend was similar in total yield. Fruit filling was better in fruits produced with black polythene, soil mulching, coir dust, and saw dust treatments. These findings support Chaudhry et al. (2004). They reported that mulching treatments had a significant effect on plant growth and yield parameters, but intensity was different depending on the treatment. According to these findings the highest total yield and better fruits were given by black polythene, soil mulching, coir dust, and saw dust treatments.

Soil Moisture

Pineapple has a shallow root system and the effective root zone is in the 15cm to 45cm depth (Ekern, 1962). Moisture content in the effective root zone is critical for the optimum pineapple yield. Mulching had a significant effect (Table 6) on the soil moisture content at 30 cm depth at the harvesting stage. Highest soil moisture at the 30cm depth at harvesting in the coir dust mulching was not different from paddy husk, black polythene, and soil mulching treatments. However, there was no difference in moisture content in any other stage in the tested depths. Soil moisture data showed a decreasing trend with the increase of the plant age and biomass production. This is in agreement with

Table 5 - Yield parameters and yield.

Treatment	FL cm PC	FG cm PC	Yield t/ha PC	FL cm RC	FG cm RC	Yield t/ha RC
Rice straw	19.4	36.9	21.2	17.0	35.9	17.0
Saw dust	20.7	37.9	23.1	18.0	35.9	19.3
Paddy husk	19.9	37.2	21.2	17.9	35.8	19.5
Coconut husk	17.6	36.2	19.4	17.2	35.7	17.5
Black polythene	20.7	38.1	24.3	18.4	35.5	19.5
Soil mulching	19.0	36.9	22.4	17.2	35.2	19.0
Control – Fresh Coir dust	20.6	36.8	22.9	18.1	35.2	19.0
Poultry litter	18.9	35.4	19.4	17.9	34.7	18.0
Pr>F	Ns	**	**	Ns	ns	***
LSD	-	1.4	2.5	-	-	1.2

FL – Fruit length, FG- Fruit girth, PC – plant crop (First crop), RC- ratoon crop. *** Significant at the 0.001 level of probability. ns – Not significant at the 0.05 level of probability

Table 6 - Soil moisture content in different depths.

Treatment	3 MAP 15cm	3 MAP 30cm	6 MAP 15cm	6 MAP 30cm	At harvest 15cm	At harvest 30cm
Rice straw	11.6	13.0	13.2	12.1	7.5	8.3
Saw dust	11.2	12.7	12.3	13.8	8.9	8.9
Paddy husk	11.1	12.5	12.1	13.3	10.2	10.4
Coconut husk	10.5	12.1	12.1	12.2	8.4	7.2
Black polythene	10.6	12.0	11.9	13.1	9.3	10.4
Soil mulching	10.9	11.4	11.8	12.7	9.2	9.4
Control – Coir dust	13.1	11.2	11.5	14.2	10.7	10.9
Poultry litter	11.4	11.1	11.1	12.2	7.9	8.9
Pr>F	Ns	ns	Ns	Ns	Ns	**
LSD	--	--	--	-	-	1.7

ns- Not significant at the 0.05 level of probability. ** Significant at the 0.01 level of probability.

Chaudhry *etal.*; (2004) and Klocke (2004) who reported that vegetation increased the evapotranspiration and decreased the soil moisture storage.

Soil Temperature

Water near the soil surface readily evaporates at a rate that is only limited by the energy available (Klocke, 2004). Soil temperature is an important factor for this process. Evaporation under a given atmospheric evaporativities is affected more by temperature than the wind speed (Jilata, 1993). In this study, mulches influenced the soil temperature differently (Table 6) and subsequently contributed differently to conserve the soil moisture. Black polythene had the highest soil temperature at 3MAP both morning and evening and morning at 6MAP, but the polythene layer had worked as a vapor barrier to retain moisture.

In rain fed crops, the largest rate of soil water evaporation occurs when the soil surface is wet and it is controlled by the radiant energy. Mulches have the capacity to modify the radiant energy reaching the soil surface and reduce the soil water evaporation during the "energy" limited phase of evaporation. A mulch insulates and protects soil from drying and hard-baking effects caused by evaporation of water from soil exposed to hot sun and winds. Therefore, mulched soils are cooler than non-mulched soils and have less fluctuation in soil temperature. This was observed in the study as a variation between treatments (Table 7). In most instances high temperatures were recorded in the black polythene treatment, but with the groundcover it retained soil moisture equals to the coir dust treatment. Optimum soil temperatures and less moisture evaporation from the soil surface enable plants to grow better. This was significant in (Table 5 and 6) coir dust, soil mulch, black polythene and paddy husk treatments which retained a great amount of moisture and produced higher yields than in other treatments.

Bare soil with no crop canopy receives much more energy than a mulched soil under a crop canopy. Accumulating crop residues with the crop growth, or purposely-added mulch would reduce the energy reaching the evaporating surface (Ekern, 1962). This was evident throughout the experiment (Table 7). This is in agreement with Kalpcker (2004) who reported that the singular contributions of the mulch and crop canopy, each acting alone, were the same. It was further stated that the reduction in evaporation by mulch compared with the bare soil was more under the canopy than without the canopy. This is supported by the decreasing trend in soil temperature with the increase of the canopy cover (Table 7).

Soil mulching used in the experiment is different to the conventionally used earthing-up in the agriculture. In soil mulching mound is formed away from the base of the plant, but directly over the effective root zone. In the extreme dry conditions it also helps to form a temporary crust surface over the root zone. The reflectance of a mound surface can be higher than that for un mound surface in a hot sunny day (USDA, 1996). Higher reflectance results in less absorption of energy from the sun. This may results in a cooler soil surface and decreases the rate of evaporation. Further, the temporary formed crusts decrease water loss because less of their surface area is exposed to the air than a tilled soil. When crusts become dry, they become barriers to evaporation by retarding capillary movement of water to the soil surface. Similar observations had been made by Sackschewsky (1995) and reported that sand and gravel mulch increased soil-column water storage and decreased evapotranspiration compared with a plain soil surface.

Pineapple is recommended for planting along contours. With soil mounds numerous contour ridges are formed in a plantation. This will minimize the surface runoff and increase the onsite water storage. As pineapple roots are very shallow, the plants tend to lodge especially under conditions of flatbed planting. Lodging of plants when the fruits are developing would result in lopsided growth, uneven development and ripening of fruits. Lodging is more serious in ratoon crops, as the base of the plant shifts-up, crop after crop. In this situation, soil mounding helps to anchor plants better by forming a ridge in either side of the plant.

Table 7 - Soil temperature C^0 at 15cm depth

Treatment	3 MAP 15cm depth am	3 MAP 15 cm depth pm	6 MAP 15cm depth am	6 MAP 15cm depth pm
Rice straw	31.7	33.1	28.3	30.4
Saw dust	31.9	34.0	29.8	30.7
Paddy husk	31.3	34.1	29.1	30.4
Coconut husk	31.0	33.2	27.7	29.5
Black polythene	33.1	36.0	29.5	30.5
Soil mulching	31.6	35.3	28.6	31.2
Control – Coir dust	31.1	33.2	28.3	30.2
Poultry litter	32.6	34.4	28.7	30.6
Pr>F	*	***	***	**
LSD	1.2	0.7	0.7	0.6

MAP: months after planting. *** Significant at the 0.001 level of probability

CONCLUSIONS

Experimental data showed that coir dust, soil mulch, black polythene, and sawdust had the similar impact on soil moisture plant growth and total yield. It basically denotes the availability of more moisture at the root zone and its surrounding areas and in turn stimulates a host of benefits to the entire ecology. During on farm demonstrations, because of minimum expense and convenience growers accepted soil mulching /mounding as the best substitute for coir dust mulching. Therefore, it can be concluded that soil mulching /mounding treatment is the best substitute for coir dust mulching in pineapple in wet and intermediate agro ecological regions. However, if it is not expensive and does not influence the cost of production significantly coir dust mulch is still a valid option.

ACKNOWLEDGEMENTS

The authors wish to express sincere thanks and gratitude to Dr. Sydney Fernando, former Deputy Director RARDC, Makandura for his encouragement, necessary support and guidance to complete this paper successfully.

REFERENCES

Amarasing, U. A., L. Matuwatta and R. Sakthivadivel. 1999. Water scarcity variations within a country: A case study of Sri Lanka. International Water Management Institute, Research Report 32.

Chaudhry, M. R, A.A. Malik and M. Sidhu. 2004. Mulching Impact on Moisture Conservation –Soil Properties and Plant Growth. Pakistan Journal of Water Resources, Vol.8 (2)

DOA. 1999. Minutes of the 08th Fruit Crop Coordinators Meeting. Department of Agriculture, Peradeniya, Sri Lanka.

Ekern, P.C. 1962. Net radiation balance over pineapple plants on Oahu, Hawaii. J.Geophys. Res. 67: 3532.

Jilata, S.K. 1993. Evaporation through a soil mulch in relation to mulch characteristics and evaporativity. Australian Journal of Soil Research 31(2) 131 – 136

Klocke., N.L. 2004. Water savings from crop residue in irrigated corn. In Proceedings. Central Plains Irrigation Conference. Kearney, NE. Feb. 17-18, 2004. 133-141.

Kobayashi, T., W. He and H. Nagai. 1998. Mechanisms of evaporation from soil with a dry surface. Hydrological Processes, vol. 12, Issue 13, pp.2185-2191.

Sackschewsky, M.R., C.J. Kemp., S.O. Link and W.J. Waugh. 1995. Soil water balance changes in engineered soil surfaces. J. Environ. Qual. vol. 24, no2, pp. 352-359.

Sideris, C.P and B.H. Krauss. 1936. The classification and nomenclature of groups of pineapple leaves, Sections of leaves and section of stems based on morphological and anatomical differences. Pineapple Quarterly (6):135-147.

Stewart, D. 2005. The effect of soil and irrigation management on grapevine performance. MSc. Thesis. University of Adelaide, Australia.

USDA. 1996. Soil Quality Indicators: Soil Crusts. National Soil Survey Center in cooperation with the Soil Quality Institute, NRCS, USDA,