INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2004/06–3–520–524
http://www.ijab.org

Influence of Type of Mulch Material on Distribution and Accumulation of Nutrients in Sweet Potato (*Ipomoea batatas*) in Samoa

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ABSTRACT

The influence of type of mulch material on the distribution and accumulation of nutrients in sweet potato (*Ipomoea batatas*) grown in Samoa was investigated and compared with available data. The treatments were: 1) control (no mulch); 2) guinea grass (*Panicum maximum*); 3) mixture of guinea grass/dadap leaves; 4) dadap leaves (*Erythrina* spp.) and 5) poultry manure. Except for the tuber, moisture content was high in other parts. The petiole had more moisture than other parts and the type of mulch material had significant influence ($P<0.05$). Mean crude protein (CP) of leaves (26.3±3.32) was significantly ($P<0.05$) higher and type of mulch material influenced its content. Crude fiber (CF) was higher in the stem and petiole. Type of mulch material had a slight effect on ether extract content. Ash was higher in the petiole, leaves and whole plant than in stems and tubers. Except for the petiole, P content was lower than the 0.38 g kg^{-1} suggested as adequate to meet requirement of the dairy cow. The concentration of K and Mg in all parts were low. Ca concentration was lower in the tubers; however the aerial part contained an appreciable amount of Ca. The type of mulch material influenced the concentrations of Fe, Mn, Cu and Zn among the parts (($P<0.05$). Type of mulch material influenced nutrients and macro-minerals, but this was greater in trace mineral concentrations in parts of sweet potato. In conclusion the CP and gross energy (MJ/kg DM), macro and trace mineral contents of the aerial parts, makes sweet potato an ideal cheap protein and energy source in grazing ruminant livestock and human diets.

Key Words: Sweet potato; Mulch; Nutrients; Macro minerals; Micro minerals, Ruminant

INTRODUCTION

Mulching can alleviate some of the problems of decreasing soil fertility faced by smallholder farmers in the Pacific Island countries. Mulch contributes to the growth and yield of crops through conservation of moisture, suppression of weeds and supply of nutrients from organic matter (Asghar *et al.*, 1985). The use of the leaves of browse species as mulch material functions as fertilizer by adding nitrogen and other nutrients to the soil (Weeraratna, 1990; Weeraratna & Asghar, 1993). On the other hand, the application of poultry manure as mulch have tremendous potentials for the control of root nematodes and increase both growth rate and yield of crops.

Sweet potato is one of the five most important food crops in developing countries and is grown by smallholder farmers as a dual-purpose crop. Traditionally, it is grown exclusively for the production of the tubers and the foliage is considered as a waste and therefore underutilized (Moat & Dryden, 1993), however the vines can be fed to livestock (Scott, 1992) while the tubers are used for human food (Karachi, 1982). In developing countries sweet potato vines are mainly used as an animal feed wherever they are produced.

The productive dry matter (DM) potential per hectare of certain varieties of sweet potato vines can be as high as 4.3 to 6.0 tonnes/crop (Dominquez, 1992). The forage accounts for approximately 64% of fresh biomass (Pinchinat, 1970). The forage (leaf, petiole & stem) contains between 11–17% crude protein.

Sweet potato tuber and leaf are important in human food, while the whole forage is used as animal feed in the tropical countries where it is cultivated. Its importance in human and livestock nutrition therefore makes it imperative to contribute to a better understanding of the nutrient content and utilization of fractions/residues generated and wasted annually. This study therefore aims at investigating the influence of type of mulch material on the distribution and accumulation of nutrients in parts of sweet potato (*Ipomoea batatas*) grown in Samoa.

MATERIALS AND METHODS

Site and soil type. The trial was established in March 2001 in a small area (0.04 ha) selected in the experimental site of Crop Science Department, The University of the South Pacific, School of Agriculture, Alafua Campus, Apia. The soil in this area has been classified as a type humitropet, derived from weathered basalt flow rock with some colluvium from surrounding hills. The soil is high in organic carbon and total nitrogen, low in potassium and has moderate amount of exchangeable bases (Morrison *et al.,* 1986; Poasa, 1999).

Experimental design and plant culture. Five treatments namely: 1) control (no mulch), 2) guinea grass (*Panicum maximum*) mulch, 3) mixture of guinea grass/dadap leaves mulch, 4) dadap leaves (*Erythrina* spp.) mulch, 5) poultry manure mulch were tested. The randomized block design was used for laying out the treatments and these were replicated four times to give a total of twenty experimental plots. Forty kilograms of each of the mulch material was applied to each plot a week before planting

The plots were 5.0 m x 4.0 m with five rows of sweet potato. Plant spacing between rows was 1 m x 1 m and 0.5 m away from the boarder line. In each plot there were 20 mounds planted with two sweet potato vines (5 cm). These were planted between, March 29th – 30th 2001. Sprouting of sweet potato vines started five days after planting.

Maturity, harvesting and processing of morphological parts. The sweet potato got matured for harvesting at four months. Aerial samples, whole plant and tubers were harvested from each plot and a known quantity of each was sampled from each of the five treatments and processed. The aerial part was separated into leaves, stems and petioles. Representative samples of each aerial parts, whole plant and tubers from respective treatments were chopped with a bush knife into smaller pieces after which about 25% of each were taken for drying using a forced-air oven at 70ºC for 48 h. The dry leaves; stems; petioles; whole plant and tuber from each treatment were then ground using a simple laboratory mill (Christy & Norris; Process Engineers, Chelmsford, UK) to pass through 1 mm sieve and stored in air tight bottles until required for analysis.

Chemical analysis of constituents. The AOAC (1995) method was used for nutrient contents of samples. Dry matter was determined by drying at constant weight at 70ºC for 48 h in a forced-air oven, ash by incineration at 600ºC for 3 h, protein by the micro-Kjeldahl procedure (N x 6.25). The fibre content of the products was determined by a modification of the neutral detergent method (Holloway *et al.*, 1977). Macro and trace minerals were determined by digesting samples in $HNO_3/HClO_4$ using an atomic absorption spectrophotometer (GBC 908 AA, Scientific Equipment Pty Ltd, Dandenog, Victoria, Australia) to detect Ca, Mg, P, Mn, Zn, Cu and Fe. Potassium was determined using a flame photometer (Ciba-Corning Flame Photometer 410) as described in AOAC (1995). All analyses were done in triplicate.

Table I. Influence of type of mulch on nutrient distribution and accumulation in parts of the sweet potato Nutrients*

Parts	Mulch/Treatments	DM	CP	CF	EE	Ash	Gross energy(MJ/kg DM)
Leaves	Control	21.5	20.5[2]	8.1	2.3	9.7	13.8
	Guinea grass	22.8	24.6[1,2]	8.7	2.5	10.4	13.8
	Guinea grass/dadap	22.7	27.8[1]	9.4	3.2	10.5	14.1
	Dadap	23.7	29.5[1]	11.0	3.0	10.9	14.9
	Poultry manure	24.7	28.8[1]	10.3	3.5	11.5	14.5
	Mean (±SD)	23.1±1.03[b]	26.2±3.32[a]	9.5±1.04[c]	2.8±0.44	10.6±0.59[a]	14.2±0.43
Petioles	Control	10.3	11.1	15.7	1.8	12.9	11.4
	Guinea grass	10.1	11.3	16.2	1.7	13.6	11.4
	Guinea grass/dadap	10.2	11.6	16.4	1.9	12.7	12.1
	Dadap	13.5	12.8	18.4	1.8	13.8	12.9
	Poultry manure	11.2	12.3.	16.5	1.8	11.5	12.5
	Mean (±SD)	11.1±1.28[d]	11.8±0.64[c]	16.6±0.92[b]	1.8±0.16	12.9±0.81[a]	12.1±0.59
Stems	Control	20.8	12.6	19.5	3.3	6.8	13.1
	Guinea grass	21.5	13.5	21.0	3.1	6.8	13.2
	Guinea grass/dadap	21.1	11.8	22.5	2.7	6.9	13.4
	Dadap	24.1	14.6	19.8	2.1	7.2	14.0
	Poultry manure	21.8	12.6	21.5	3.2	7.4	14.0
	Mean (±SD)	21.9±1.17[b]	13.0±0.96[c]	20.9±1.10[a]	2.9±0.44	7.0±0.24[b]	13.3±0.36
Whole plant	Control	17.8	14.7	16.6	2.3	10.0	12.9
	Guinea grass	18.0	16.5	16.3	2.8	10.4	13.1
	Guinea grass/dadap	18.3	17.1	15.6	2.6	10.0	13.8
	Dadap	20.4	19.0	14.8	2.5	10.2	13.4
	Poultry manure	18.7	17.9	15.0	2.4	10.1	13.2
	Mean (±SD)	18.6±0.93[bc]	17.1±1.46[b]	15.7±0.70[b]	2.5±0.17	10.0±0.47[ab]	13.3±0.31
Tubers	Control	30.3	6.8	3.2	1.6	3.4	12.6
	Guinea grass	31.7	7.8	3.3	1.8	3.6	12.8
	Guinea grass/dadap	32.1	7.8	3.4	1.9	3.8	13.0
	Dadap	34.0	8.8	3.7	1.8	3.9	13.4
	Poultry manure	31.7	8.2	3.8	1.8	3.9	13.6
	Mean (±SD)	31.9±1.19[a]	7.9±0.65[d]	3.5±0.23[d]	1.8±0.09	3.7±0.19[c]	13.1±0.37

*DM, dry matter; CP, crude protein; CF, crude fibre; EE, ether extract;[a,b] Means within the same column with different superscript differ significantly (P<0.05).;[1,2] Means within the treatments for each variable of different superscript differs (P<0.05).

Statistical analysis. Data on proximate chemical composition and mineral contents of the different morphological parts were subjected to analysis of variance (ANOVA) for completely randomized block designs. Comparisons were made among the different treatments for each part (Steel & Torrie, 1980) and where significant differences occurred treatment means were compared with Duncan's multiple range tests.

RESULTS AND DISCUSSION

Sulifoa (2001) reported that different mulch materials (guinea grass, guinea grass/dadap, dadap, & poultry manure) had no effect on yield and other yield related characteristics of sweet potato, however, the number of leaves and secondary vines obtained at the harvest time in 4 months were more in two of the mulch materials. The major issue in this investigation was to assess the influence of type of mulch material on the distribution and accumulation of nutrients in parts of sweet potato (*Ipomoea batatas*) grown in Samoa.

Data on nutrient contents of leaves, stem, petiole, whole plant and tuber is presented in Table I. Except in the tuber moisture content was high in the aerial parts. The high moisture was due to the low dry matter contents of leaf, petiole, stem and whole plant. However, the petiole had more moisture content and the difference between it and other parts was significantly different ($P<0.05$) among the mulch type. The moisture content for vines reported in this trial was similar to values given by Semenye and Hutchcroft (1992) for fresh vines.

The type of mulch had significant effect on CP content of the leaf portion of the sweet potato ($P<0.05$). The leaves had a mean CP value of 26.2±3.32% and this value was similar to that reported by (Devendra & Gohl, 1970; Gohl, 1981; FAO, 1989; Orodho *et al.*, 1993) for sweet potato leaves grown in other tropical environment. The high CP content of the leaves endowed its usage as a valuable vegetable addition in human diet (FAO, 1989) and also as a cheap source of protein in livestock nutrition (Gohl, 1981; Karachi & Dzowela, 1990; Orodho *et al.*, 1993; Aregheore, 2004).

Sweet potato leaves are rich in carotenes, provitamin A and calcium and in human nutrition they are usually eaten boiled or fried with onions, tomatoes and spices as a side dish, or may simply be added to the soup or stew (FAO, 1989). In ruminant nutrition, the leaves are used as a protein supplement to low quality forage (Orodho *et al.*, 1993; Aregheore, 2004). Orodho *et al.* (1993) reported that the value of sweet potato vines is attributed to its high yield,

Table II. Influence of type of mulch material on macro mineral concentrations (g kg^{-1}) of sweet potato parts Macro minerals*

Parts	Mulch/Treatments	P	K	Ca	Mg
Leaves	Control	0.22	0.08	1.78	0.05
	Guinea grass	0.22	0.09	2.04	0.05
	Guinea grass/dadap	0.24	0.09	2.20	0.06
	Dadap	0.27	0.10	2.46	0.08
	Poultry manure	0.27	0.10	2.58	0.07
	Mean (±SD)	0.24±0.02	0.09±0.01	2.12±0.29	0.06±0.01
Petioles	Control	0.40	0.14	1.44	0.03
	Guinea grass	0.42	0.15	1.71	0.03
	Guinea grass/dadap	0.44	0.17	1.75	0.04
	Dadap	0.44	0.18	1.84	0.04
	Poultry manure	0.47	0.17	2.23	0.04
	Mean (±SD)	0.43±0.02	0.16±0.01	1.79±0.26	0.04±0.01
Stems	Control	0.27	0.07	0.77	0.02
	Guinea grass	0.29	0.08	0.74	0.03
	Guinea grass/dadap	0.29	0.08	0.74	0.03
	Dadap	0.35	0.08	1.08	0.03
	Poultry manure	0.30	0.08	1.13	0.04
	Mean (±SD)	0.30±0.27	0.08±0.00	0.89±0.17	0.03±0.01
Whole plant	Control	0.31	0.10	1.33	0.03
	Guinea grass	0.33	0.10	1.51	0.04
	Guinea grass/dadap	0.33	0.10	1.68	0.05
	Dadap	0.32	0.12	1.71	0.04
	Poultry manure	0.35	0.11	1.94	0.06
	Mean (±SD)	0.32±0.01	0.11±0.01	1.63±0.20	0.04±0.01
Tubers	Control	0.18	0.03	0.13	0.01
	Guinea grass	0.18	0.03	0.18	0.01
	Guinea grass/dadap	0.18	0.04	0.26	0.01
	Dadap	0.18	0.04	0.41	0.01
	Poultry manure	0.13	0.05	0.43	0.01
	Mean (±SD)	0.17±0.02	0.04±0.01	0.25±0.09	0.01±0.00

*P, phosphorus; K, Potassium; Ca, calcium; Mg, magnesium

Table III. Influence of type of mulch material on micro mineral concentrations (mg kg^{-1}) of sweet potato parts Micro minerals*

Parts	Mulch/Treatments	Fe	Mn	Cu	Zn
Leaves	Control	186.8^{4}	112.2	9.9	17.9
	Guinea grass	186.8^{4}	126.8	10.9	18.9
	Guinea grass/dadap	200.2^{3}	140.9	11.8	28.7
	Dadap	293.6^{1}	203.7	11.8	35.8
	Poultry manure	233.8^{2}	156.4	13.9	28.4
	Mean (±SD)	220.2±40.51^{a}	148.0±31.48^{a}	11.7±1.32^{a}	25.9±6.71^{a}
Petioles	Control	106.8^{4}	23.7	8.9	10.2
	Guinea grass	126.7^{3}	31.9	8.9	11.2
	Guinea grass/dadap	133.4^{2}	42.2	8.9	27.3
	Dadap	166.7^{1}	43.2	11.9	43.7
	Poultry manure	133.3^{2}	39.1	9.9	28.4
	Mean (±SD)	133.4±19.29^{e}	36.0±7.32^{c}	9.7±1.17^{a}	24.2±7.38^{a}
Stems	Control	133.4^{5}	14.4	9.9	19.9
	Guinea grass	146.8^{4}	16.5	10.9	22.1
	Guinea grass/dadap	160.1^{3}	25.7	10.9	22.8
	Dadap	467.4^{1}	22.6	11.9	29.4
	Poultry manure	180.1^{2}	17.5	11.9	52.2
	Mean (±SD)	177.8±47.31^{c}	19.3±4.14^{d}	11.1±0.75^{a}	27.3±6.88^{a}
Whole plant	***Control***	151.2^{4}	50.0	9.6	22.3
	Guinea grass	162.4^{3}	58.4	10.2	25.2
	Guinea grass/dadap	169.1^{3}	74.8	10.7	26.5
	Dadap	298.1^{1}	89.8	11.9	30.4
	Poultry manure	171.2^{2}	65.8	11.6	27.9
	Mean (±SD)	190.4±54.29^{b}	67.8±13.73^{b}	10.8±0.86^{a}	26.5±2.70^{a}
Tubers	Control	126.7^{5}	43.2	3.9	7.0
	Guinea grass	133.4^{4}	44.3	4.9	11.6
	Guinea grass/dadap	140.2^{3}	43.8	5.9	11.9
	Dadap	166.7^{1}	48.3	5.9	16.8
	Poultry manure	160.1^{2}	48.2	6.7	25.9
	Mean (±SD)	145.4±15.43^{d}	45.5±2.24^{c}	5.5±0.97^{a}	14.6±6.43^{b}

*Fe, iron; Mn, Manganese; Cu, copper: Zn, Zinc.; ^{a,b,c,d} Means within the same column with different superscript differ significantly (P<0.05).; ^{1,2,3,4,5} Means within the treatments for each variable of different superscript differs (P<0.05).

palatability and crude protein content.

Crude fibre (CF) content was higher in the stems and petioles, however the type of mulch material had no effects on its contents in different parts of sweet potato. Although it has been reported that sweet potato vines are suitable herbage for young calves (Orodho *et al.*, 1993), the high CF content of the petioles and stems may however affects its digestibility.

Ether extract (EE) content was slightly different among the parts and the type of mulch material seems to have some influence but the differences observed were not significant (P>0.05). Ash content was higher in the petioles, leaves and whole plant than in the stems and tubers.

The CF, EE and ash contents of the sweet potato investigated in this trial are similar to values reported by Oyenuga (1968), Devendra and Gohl (1970) and Gohl (1981) for sweet potato grown in West Africa and the West Indies. Type of mulch material had no significant influence on CP and GE contents of sweet potato tuber. The CP content of sweet potato tubers reported in this trial was relatively high compared to other tropical roots/tubers such as yams and cassava. Nutritionally sweet potato has rather higher protein content than other tubers (FAO, 1989). Sweet potato is one of the five major food crops in developing countries and the high CP and GE contents of the leaves and tubers, respectively makes it a favorable cheap source of protein and energy in the diets of humans and livestock in the developing countries.

The role of minerals in both human and livestock nutrition have been stressed (FAO/WHO, 1974; McDowell, 1985). Sweet potato is a dual-purpose crop and, its importance in supplying the mineral needs of both human and livestock is not yet appreciated. The macro and trace minerals in parts of the sweet potato are presented in Table II.

In human and livestock nutrition, phosphorus (P) and calcium (Ca) are important macro minerals. P content was more in the petiole portion than in other parts, however, the difference was not significant (P>0.05). Except for the petiole, overall P concentration was lower than the 0.38 g kg^{-1} level suggested as adequate to meet the requirement of the dairy cow but not of beef cattle, goats and sheep. Generally, P concentration is low in Samoa (Aregheore & Hunter, 1999) and it was assumed that the different mulch materials would improve its distribution and accumulation in the soil and subsequently in the sweet potato tissues, but this was not the case.

K and Mg concentrations in all parts were also lower than critical levels suggested as adequate for the dairy cow, beef cattle, sheep and goats (NRC, 1980; McDowell, 1985;

McDowell *et al.,* 1993). Except in the tubers, the concentration of Ca in other parts was higher than levels suggested by NRC (1980) and McDowell (1985) to meet the requirements of the dairy cow, grazing beef cattle, sheep and goats. This therefore demonstrated that the aerial part of sweet potato contains an appreciable amount of Ca to meet the requirements of ruminant livestock.

Table III presents the influence of type of mulch material on trace mineral concentration of sweet potato. Fe, Mn, Cu and Zn concentrations in different parts were significantly different (P<0.05) from each other and type of mulch material seems to have significant influence (P<0.05) on their concentrations. The dadap mulch had significantly (P<0.05) high concentration of Fe in all parts than other mulch types. The aerial parts of the sweet potato met the Fe, Mn, Cu and Zn requirements of grazing ruminant and humans (FAO/WHO, 1974; NRC, 1980; McDowell, 1985).

Ca and Fe concentrations in both the leaves and tubers are higher than levels suggested as adequate by the FAO/WHO (1974) expert group on Ca and Fe requirements for all ages in humans. The high CP and GE content of aerial parts, coupled with the concentration of macro and trace minerals demonstrated further the important role of sweet potato as a cheap source of protein and energy in livestock and human diets. In conclusion the type of mulch material used had little influence on the distribution and accumulation of available nutrients and macro-minerals, however, they seems to have significant influence on trace mineral concentrations of sweet potato.

Acknowledgement. The authors are grateful to Mr. Sulifoa, J.B. for technical assistance in the harvest and processing of samples and also to Mr. Daya Perera, The Senior Laboratory Technician and staff of the Agricultural Chemistry Laboratory, The University of the South Pacific, School of Agriculture, Alafua Campus for chemical analyses.

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(Received 25 March 2004; Accepted 15 April 2004)