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Craig Elevitch and Kim Wilkinson. AgroForester (formerly Source Ecosystems), P.O. Box 428, Holualoa, Hawaii 96725 USA, Tel: 808-324-4427, Fax: 808-324-4129, email@agroforester.com, http://www.agroforester.com

Bruce Mathews, Assistant Professor of Soils and Agronomy, University of Hawaii, Hilo, 200 W. Kawili St., Hilo, Hawaii 96720-4091, USA, Tel: 808-974-7393, Fax: 808-974-7674, bmathews@hawaii.edu

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Contour Hedgerows of Nitrogen Fixing Trees for Mulch Production in a Jackfruit Orchard

Introduction

This project, conducted on-farm in Holualoa, Hawai'i, studied alley cropping with fruit tree crops in the subhumid tropics. By cycling nutrients in the agricultural system, alley cropping in an orchard setting holds promise for greatly reducing, and possibly eliminating, the need for certain manufactured or imported fertilizer inputs, replacing them with an on-site organic source of fertility.

Research focused primarily on the ability of the alley cropping technique to provide sufficient nutrients to tree crops.

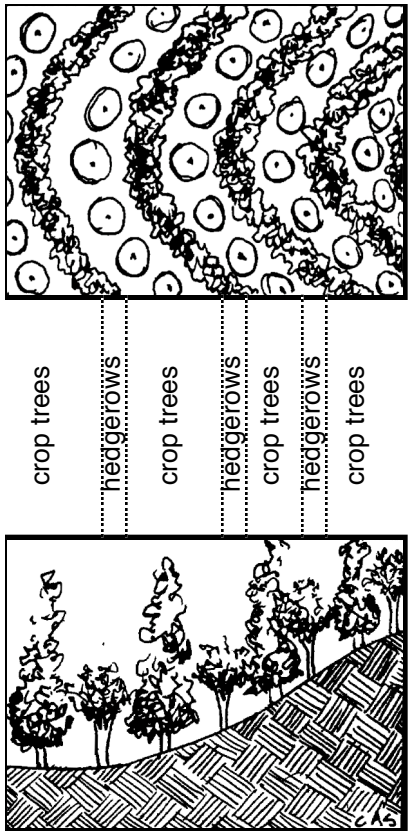
Materials and Methods

Site. The project was conducted on a private farm located at an elevation of 400 m on the leeward side of the Island of Hawaii (Lat.: 19°40´, Long:155°55´). The mean annual rainfall is 1650 mm, and the mean annual temperature is 20°C, (annual minimum 9°C, maximum 32°C). The soil is classified as medial-skeletal isohyperthermic lithic haplustands in the Waiaha series. The soil series is extremely stony, well-drained, silty clay loam, derived from volcanic ash and an a'a lava flow (ca 10,000 years old). The area was cleared and rolled with a bulldozer in 1993, and planted with permanent ground cover of centipede grass (*Eremochloa ophiuroides*). Previous to clearing, the area was fallow or managed organically for at

least 20 years.

Planting Configuration. In alley cropping, fast growing, nitrogen-fixing trees are grown together with crops to provide an abundant source of organic matter which is applied to the soil around the crops. The practice has been studied extensively with annual crops such as rice, soybeans and maize. Although alley cropping with perennial crops has been suggested (e.g. IIRR, 1990), relatively little research has been devoted to hedgerows integrated with tree crops. In Sri Lanka, the NFTs *Gliricidia sepium* and *Leucaena leucocephala* integrated into a coconut plantation and used for mulch significantly increased copra production (Liyanage, 1987). Alder, a temperate climate NFT, when planted in hedges was shown to have a favorable effect on nitrogen nutrition of neighboring apples (Delver, 1968).

In this project, fruit trees (*Artocarpus heterophyllus,* jackfruit) were planting in the alleys between the hedgerows (*Acacia angustissima* and *Calliandra calothyrsus*). The planting arrangement is depicted in Figure 1. The hedgerows were pruned to supply mulch material, which was placed in a circle around the orchard trees. This planting configuration was thought to have several advantages over alley cropping with annual crops, including maximizing the distance between hedgerows and crops, and concentrating the organic matter to a small area around the crops.



Measurement of Prunings. Two hedgerow species, *Acacia angustissima* and *Calliandra calothyrsus* were planted in 8 m sections. One four meter section of each hedgerow species was selected at random for each block at the outset of the project for measurements of the organic matter produced (three four-meter sections for each species, total). When the height of the hedgerow trees reached approximately 3-4 m, the hedgerows were pruned back. For each measurement area, the 4 m of hedgerow were cut back and separated into green leafy material (stems less than 1 cm diameter), and woody material (stems greater than 1 cm). After weighing these two parts of the prunings, a subsample was taken from each. The subsample consisted of 3-4 stems selected at random, and hand chopped to pieces less than 8 cm. These chopped pieces were dried in paper bags at approximately 37 C°, until dry to the touch, and then sent to a commercial lab for final drying at 60 C°, milling, and nutrient analysis. The lab determined N colorimetrically by Kjeldhal digestion. And the minerals in nitric acid digest were determined by plasma emission spectroscopy (Jones & Case, 1990). Jones, J.B. Jr. and V.W. Case. 1990. Sampling, handling, and analyzing plant tissue samples. pp 389-427. in R.L. Westerman, ed. Soil Testing and Plant Analysis, 3rd Edition. SSA, Book no. 3, SSA, Madison, WI.

Soil Sampling. Because these soils are extremely rocky, extracting soil cores is not possible. Instead, a steel digging implement (shaped like a large dagger) was used to scrap away the surface debris (approximately 1 cm of surface soil, plus leaf litter, mulch, etc.), and then dig a hole about 5 cm in diameter and 20 cm deep. About 2 dl of soil was scraped vertically from the sides of the hole, and put into the collection container. Each sample submitted for analysis is a composite of 10 such samples taken from several areas which had the same treatment. The samples were analyzed for extractable P, K, Ca, and Mg at a commercial lab by the Mehlich method (Donohue, 1992), and total N and organic carbon by the University of Hawaii at Manoa ADSC laboratory (Hue, et al, 1998).

Statistics. The data were analyzed statistically using SAS.

Results and Discussion

Organic Matter Production. Hedgerow prunings took place 10/96, 4/97, 7/97 and 11/97. The mulch from each of 3 test plots (4 meter sections of hedgerow) for each tree species were weighed. Nutrient concentrations and moisture content of small samples of leaf mulch and woody matter for each tree species were analyzed 10/96 and 11/97. Results for the the three prunings during 1997 are presented below.

Nutrients in mulch tissue:

Mean values for three samples	%N	%P	%K	% Mg	%Ca	%S	B ppm	Zn ppm	Mn ppm	Fe ppm	Cu ppm
Acacia angustissima leaf	4.03	0.26	1.28	0.19	0.67	0.18	29	34	33	73	8
Acacia angustissima wood	0.67	0.06	0.53	0.04	0.23	0.11	8	13	11	179	6
Calliandra leaf	2.88	0.15	1.07	0.25	0.58	0.20	22	25	44	74	11
Calliandra wood	0.91	0.06	0.92	0.08	0.21	0.13	7	11	13	146	9

Nutrient contribution per tree during 1997 kg/tree (total three prunings):

Typical contributions from the mulch 1997 (kg/tree)	N	P	K	Mg	Ca	S
Acacia angustissima leaf	1.09	0.06	0.39	0.05	0.16	0.04
Calliandra calothyrsus leaf	0.83	0.04	0.32	0.06	0.14	0.05
Acacia angustissima wood	0.13	0.01	0.10	0.01	0.04	0.02
Calliandra calothyrsus wood	0.14	0.01	0.14	0.01	0.03	0.02
Acacia angustissima leaf & wood	**1.21**	**0.07**	**0.49**	**0.06**	**0.21**	**0.06**
Calliandra leaf & wood	**0.97**	**0.05**	**0.46**	**0.07**	**0.17**	**0.07**

Fertilizer replacement per tree during 1997 kg/tree (total three prunings):

Fertilizer replacement from the mulch 1997 (kg/tree)	Urea	Treble super phosphate	Muriate of Potash
Acacia angustissima	**2.64**	**0.17**	**0.82**
Calliandra calothyrsus	**2.11**	**0.11**	**0.76**

Total mulch production per 1000 meters hedgerow extrapolated from 1997 data (total three prunings):

Total mulch 1997 kg per 1000 meters of hedgerow	Wet weight kg	Dry weight kg
Acacia angustissima leaf & wood	**15,414**	**4,433**
Calliandra leaf & wood	**14,044**	**4,014**

Soils Data. Selected soils data for the hedgerows, crop trees (mulched and unmulched) and control area (no hedgerows or crop trees) are presented below. The P, K, Mg, and Ca data were analyzed on a ppm (mg/kg) basis.

Date	Treatment	P ppm	K ppm	Mg ppm	Ca ppm	Soil pH	% org. C	% total N
Base	Control	7	62	372	1874	6.6	6.14	0.78
7/96	In hedgerow	13	119	322	1556	6.2	6.55	0.85
7/96	Jackfruit tree, no mulch	3	188	494	1939	6.1	6.35	0.87
7/96	Jackfruit tree, mulched	3	680	460	1916	6.4	6.43	0.94
12/97	In hedgerow	4	60	334	1632	6.4	5.94	0.83
12/97	Jackfruit tree, no mulch	2	83	353	2292	6.4	5.84	0.92
12/97	Jackfruit tree, mulched	2	392	374	1586	6.3	7.03	1.06

Results of analysis:

1996 data	treatment effect	SE	CV%
P	P = 0.39; not significant	5	110
K	P = 0.0001; very significant	36	22
Mg	P = 0.11; not significant	47	19
Ca	P = 0.09; not significant	143	14
pH	P = 0.04; significant	--	24
% Organic C	P = 0.77; not significant	0.17	5
% total N	P = 0.55; not significant	0.05	9

P = probability level
SE = standard error
CV% = percent coefficient of variation.

Treatments followed by the same letter are not different for K or pH (*P*>0.05).

Hedgerows	A
No mulch	A
Mulched	B

ANOVA results show that there was a very significant effect on K during Year 1 of the trials, as availability nearly tripled in mulched trees as compared with the other treatments and control. There was also a significant effect on pH, which was moderately more neutral (pH 6.4 in mulched trees versus slightly lower values in the other treatments and control).

1997 data	treatment effect	SE	CV%
P	P = 0.51; not significant	2	85
K	P = 0.02; significant	49	49
Mg	P = 0.80; not significant	26	13
Ca	P = 0.76; not significant	318	31
pH	P = 0.46; not significant	--	38
% Organic C	P = 0.36; not significant	0.4	11
% total N	P = 0.01; significant	0.03	6

Treatments followed by the same letter are not different for K (*P*>0.05).

Control no NFT	A
Hedgerows	A
No mulch	A
Mulched	B

Treatments followed by the same letters are not different for N (*P*>0.05).

Control no NFT	A
Hedgerows	AB
No mulch	B
Mulched	C

In Year 2 there were significant effects on K and % total N. As in Year 1, available K was 3-4 times higher in mulched trees compared with other areas. Percent total N increased approximately 15% in mulch trees over other treatments and control.

Conclusion

Alley cropping in an orchard setting has shown promise in this study. Soil nutrient levels stayed the same, or improved (K, % total N) using the hedgerow prunings for mulch. Nutrients in the prunings applied as mulch contribute significant quantities of N and K, although the contribution of P in mulch is probably insufficient.

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