Cultivation of Medicinal Plants in Alley Cropping System with *Moringa oleifera* in the Virgin Islands

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Medicinal and aromatic plants (MAPs) are horticultural crops with socio-economic significance in the Caribbean. People of the Caribbean maintain the tradition of making 'bush (herb) teas' as part of their daily activity. 'Bush tea' is made with a variety of herbs that are combined for their culinary and medicinal properties. Cultivating these plants complements conventional fruit and vegetable production in the Virgin Islands and enhance small-farm productivity. This study was initiated to evaluate the agronomic and economic potential of agroforestry systems involving MAPs with focus on alley cropping. Field experiments were conducted to determine yield and productivity of popular species of medicinal plants and aromatic herbs commonly used in the Virgin Islands. Medicinal plants included 'inflammation bush' (*Verbesina alata*), 'worrywine' (*Stachytarpheta jamaicensis*) and 'japana' (*Eupatorium triplinerve*). Aromatic and culinary herbs evaluated were basil (*Ocimum basilicum*), lemongrass (*Cymbopogon citratus*), sweet marjoram (*Origanum majorana*), thyme (*Thymus vulgaris*), mint (*Mentha piperita*), cilantro (*Coriandrum sativum*) and chive (*Allium schoenoprasum*). MAPs were planted in 6-m wide alleys formed between Moringa (*Moringa oleifera*) hedgerows. MAPs were planted in 6 rows spaced 83 cm. In-row spacing was 20.3 cm for thyme, cilantro, sweet marjoram, chives and mint; and 60.9 cm for lemongrass, inflammation bush, worrywine, japana and basil. Similar spacings were used for all crops planted in monoculture system (no hedgerows). The experiment was laid out using randomized block design with 4 replications. For each crop, treatments consisted of hedgerow (alley cropping) and no hedgerow (monoculture). Data were collected on fresh and dry matter yield. *Moringa* hedgerows were pruned at 1 m above ground and biomass yield was determined using stem and leaf samples. Results indicated yield of intercropped medicinal plants and herbs were not significantly reduced during the first harvest, but yield tended to decrease in subsequent harvest suggesting that tree-crop competition was minimal during the early establishment stage. Yields of basil and worrywine were significantly ($P<0.05$) reduced in alley cropping plots, whereas, differences in yield between alley cropped and monoculture plots for inflammation bush and lemongrass were not significant ($P>0.05$) indicating that these species are not sensitive to tree-crop competition in alley cropping system. Cost and returns analysis showed that alley cropping MAPs with *Moringa* resulted in slightly lower economic benefits compared to monoculture.

Introduction

The tropical climate and natural resources of the Virgin Islands provide a great opportunity for year-round agricultural production. In spite of the ideal conditions, agricultural output, efficiency and general economy of the islands are declining. The decline in the agricultural sector can be attributed to decreasing number of horticultural farms. In addition, the devastating effects of hurricanes during the past decade on agricultural crops contributed further to the reduction in the number of farms. Furthermore, a great number of plant species have been lost including some medicinal plants due to the devastating effect of hurricanes. Despite the general decline in agricultural activity, there has been a slow increase in the number of small farms[1-3]. In 1998 a combined total of 134 farms were growing vegetables and herbs in the island of St. Croix alone. Most farms are operated by part-time growers with farm size ranging from less than one acre to 10 acres[3].

In spite of the ideal and favorable climate throughout the year, fruit and vegetable production in the Virgin Islands fall short of meeting market demands for fresh produce. Most fruits and vegetables are imported from the mainland U.S. and other countries in the Caribbean basin. It is estimated that local production constitutes only 5 to 10% of the total produce sold in the local market. The high cost of inputs (irrigation, fertilizers and pesticides) put Virgin Islands farmers at a competitive disadvantage. This results in higher retail market price of vegetables in the Virgin Islands compared to produce from neighboring island, like Puerto Rico.

Medicinal plants have been closely associated with the traditional, social and cultural events of the people in the Caribbean in general and the Virgin Islands in particular. Medicinal plants are commonly referred to as folk medicine or bush medicine in the Caribbean. Folk medicine is defined as "the substance of all the traditional viewpoints on sickness and healing methods applied against disease which exists among the people"[4]. Folk medicine in St. Croix developed out of the interactions between European and African healing systems as they were combined in the New World[5].

Today, medicinal plants are important horticultural crops in the Virgin Islands. About half of the farmers are involved in growing and producing herbs and medicinal plants. There are species and varieties that are indigenous to the Virgin Islands as well as introduced species that have been naturalized in the islands. The economic importance of these plants indicates that more research and development efforts must be undertaken to maintain and conserve germplasm materials. Research is also needed to provide herb growers with necessary technical information to help them improve production, processing, marketing and utilization. Small-scale growers in the Virgin Islands grow medicinal plants in small garden plots using less efficient planting methods. There has been no research work addressing improved crop management practices of medicinal plants. The few published materials with descriptions and culture of common and local medicinal plants focus on their growth habit and herbal uses. Some of the indigenous as well as introduced species of medicinal plants are heavily exploited and threatened to extinction.

Collection, conservation and production of medicinal plants are approaches that will maintain genetic resources and enhance diversity. Studies on cultural practices from planting to harvesting are essential for the common and important species of medicinal plants.

In the Virgin Islands, herbs and medicinal plants are grown either in the wild or cultivated in a variety of cropping systems and cultural management practices. The plants are grown at elevations ranging from flat lands to sloping hills and rolling topography. For example, in St. Thomas medicinal and culinary herbs are cultivated in small farms located in sloping lands. Some are grown in terraces as well as in bottom level lands. Cropping systems with herbs and medicinal plants are normally in mixtures or integrated into fruits and vegetables on small farms. Wild types and indigenous species are usually seen under a forest canopy.

Interest in medicinal plants has been growing among local farmers. Medicinal trees like Neem (*Azadirachta indica*), Moringa (*Moringa oleifera*) and Noni (*Morinda citrifolia*) are becoming popular in home gardens on St. Croix and St. Thomas[6-9]. Some of these trees have been grown with vegetable crops in agroforestry systems[10,11].

Cultivation of medicinal plants may offer a potential alternative to conventional fruit and vegetable production in the Virgin Islands. Although it can be a viable option for small-scale farmers, little research information is available on the merits and benefits. Farmers need information on improved species and cultivars along with recommended crop management practices for increasing yield and economic returns. This study is being conducted with the following objectives: 1) to determine the influence of tree hedgerows on growth and productivity of traditional medicinal plants and culinary herbs grown in an agroforestry systems; and 2) to evaluate the economic benefits of growing medicinal plants in an agroforestry system.

Materials and Methods

This study was conducted at the Agricultural Experiment Station, University of the Virgin Islands, St. Croix, U.S. Virgin Islands, Eastern Caribbean (lat 17°45'N, long 64°45'W). Annual rainfall ranges from 500 to 750 mm. Moringa (*Moringa sp.*) tree hedgerows were established in May 2002 by direct seeding two to three seeds per hole spaced at 1.5 m. Seedlings were thinned to one plant per hole two weeks after germination. Moringa tree hedgerows were spaced at 5 m forming 5-m alleys between hedgerows.

Four species of medicinal plants and six species of culinary herbs were used in the study. The medicinal plants were 'Japana' (*Eupatorium triplinerve*), 'Blue Verbena' or 'Worrywine' (*Stachytarpheta jamaicensis*), 'Inflammation Bush' (*Verbesina alata*), and 'Lemongrass' (*Cymbopogon citratus)*. Culinary herbs grown were Basil (*Ocimum basilicum*), Sweet Marjoram (*Origanum majorana syn Majorana hortensis*), Thyme (*Thymus vulgaris*), Cilantro (*Coriandum sativum*) Chive (*Allium schoenoprasum*) and mint (*Mentha piperita*).

Japana (*Eupatorium triplinerve* L. Vahl) is commonly grown in home gardens. This perennial medicinal plant is native to the Atlantic coast of South America and naturalized in the Virgin Islands. It is utilized in bush tea as a

"cooling" beverage and for a treatment of coughs and colds[7].

Blue Verbena (*Stachytarpheta jamaicensis* L. Vahl) is native throughout the Caribbean and can be found growing along roadsides and on disturbed sites. Locally known as "Worrywine", the fresh leaves are consumed in bush tea as a "cooling" tonic and blood cleanser, to treat "asthma" and "ulcerated stomachs"[5,7].

Inflammation Bush (*Verbesina alata* L.) is native to parts of the Eastern and Southern Caribbean. This plant can be found growing wild on disturbed sites. Commonly cultivated in home gardens, it is known as "Inflammation Bush" in the Virgin Islands. It is consumed in bush tea as a cleansing tonic, or a treatment for coughs, colds, and bruises[5,7].

Lemongrass (*Cymbopogon citratus* DC Stapf) is native to South Asia and has been introduced throughout the tropics. A perennial grass with a distinctive lemon odor, Lemongrass is used in bush teas both for flavor and medicinally to treat fevers[5]. Lemongrass is used internationally in food flavorings, aromatherapy, and the perfume industry.

Basil (*Ocimum basilicum*) is an aromatic annual or short-lived perennial herbaceous plant native to tropical Asia. A popular culinary and medicinal herb, it has been distributed worldwide. Numerous varieties have developed with varying combinations of volatile oils, ornamental foliage and adaptation to local conditions. In the Virgin Islands basil, known locally as "mint", "garden balsam", or "mosquito balsam", is cultivated for use as a cooking herb and in beverage and medicinal bush teas. A bush tea made from the leaves is used to treat stomachaches[5].

Sweet Marjoram (*Origanum majorana syn Majorana hortensis*) is a perennial sub-shrub native to the Eastern Mediterranean, often grown as an annual. It is a popular culinary herb and is used commercially in body care products and flavorings.

Thyme (*Thymus vulgaris*) is a perennial, aromatic herb native to Eurasia. Thyme species are ideally suited for the Virgin Islands, preferring stony and rocky neutral to alkaline soils. Thyme is a popular culinary herb for meat and soups and stuffings. Dried thyme leaves are used in potpourris and thyme oil is used in toothpastes and mouthwashes. Thyme also make excellent honeybee forage.

Chive (*Allium schoenoprasum*)is a handy perennial herb that grows in clusters of many small, onion-like bulbs. Chive is grown in home gardens and small vegetable farms in the Virgin Islands. It is one of the popular culinary herbs and its fresh green leaves are used to flavor almost all foods in which a mild onion flavor is desired.

Mint (*Mentha piperita*) is a hardy perennial native to Mediterranean countries. Although it is adapted to temperate climate, mint can be grown in the Virgin Islands during cool months of December to February. Fresh mint is mainly used in salads and food flavoring.

Cilantro (*Coriandum sativum*) also known as coriander is a hardy annual of the parsley family. It thrives best in weedless, fertile and deep soil. The plant has many branches and leaves are serrated. In the Virgin Islands, the fresh stem, leaves and seeds are all used in many culinary preparations and have a specific aromatic odor. The young leaves are also used to flavor soups and salads.

The trial was established in randomized block design with four replications. Treatments consisted of alley cropped plots (hedgerow) and control plots (no hedgerow). All medicinal plants and culinary herbs were sown in the greenhouse and grown until seedlings reached optimum transplant size. *Cymbopogon, Eupatorium, Ocimum, Stachytarpheta*, and *Verbesina* were planted at 61 cm in-row plant spacing. *Allium, Coriandum, Mentha, Origanum* and *Thymus* were planted on randomly assigned position in each block at 20 cm in-row plant spacings. All plants were planted at row spacing of 61cm between rows. Plot size for each species was 6 rows with 7 plants per row for the 20 cm in-row spacing (3.7 m x 1.4 m or 5.12 m^2) and 6 rows with 3 plants per row for the 61 cm in-row spacing (3.7 m x 0.6 m or 2.22 m^2). A starter soluble fertilizer (20-20-20) was applied per tree of *Moringa* hedgerows. Medicinal plants and culinary herbs were fertigated with 20-20-20 soluble fertilizer at weekly intervals. Drip irrigation was installed along hedgerows for early tree establishment. Medicinal plants and culinary herbs were drip irrigated based on soil moisture tension maintained at -30 kPa.

For *Moringa* tree hedgerows data were collected on initial germination and establishment, plant height at monthly intervals, number of side branches and biomass production at pruning. Tree hedgerows were pruned at 1 m above ground when the trees reached a height of 2 m. Regrowth was evaluated in terms of number of newly developed side shoots/branches. Medicinal plants and culinary herbs were sampled for fresh and dry weight at each harvest. Plant height was measured at first harvest. Sample size consisted of two plants in each row for perennials and 4 to 5 plants in each row for annuals. In this paper, only data from basil and lemongrass are reported for discussion purposes.

Tree-crop interaction was measured in terms of light competition. Photosynthetic active radiation (PAR) was measured across rows of herbs and medicinal plants using a hand-held Quantum Meter (Apogee Instruments, Inc., Logan, Utah, USA). Percent shading (light reduction) due to hedgerows was determined from PAR readings.

Results and Discussion

Germination and establishment of *Moringa* were excellent. As shown in Fig. 1 the trees reached a height of 1.76 m six months after planting. The length of the longest side branch was 1.6 m ten months after planting (Fig. 2).

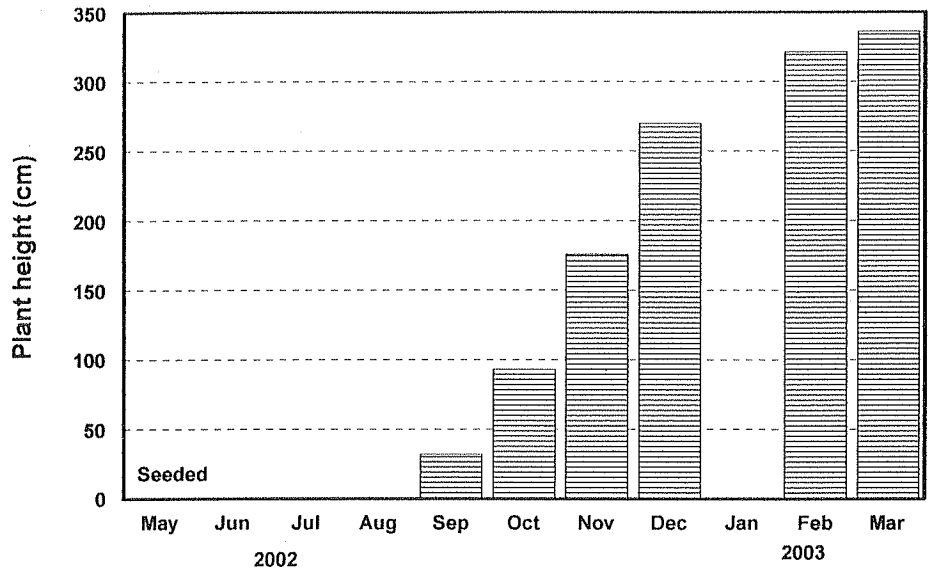

Fig. 1. Plant height of *Moringa oleifera* grown in hedgerows
St. Croix, U.S. Virgin Islands

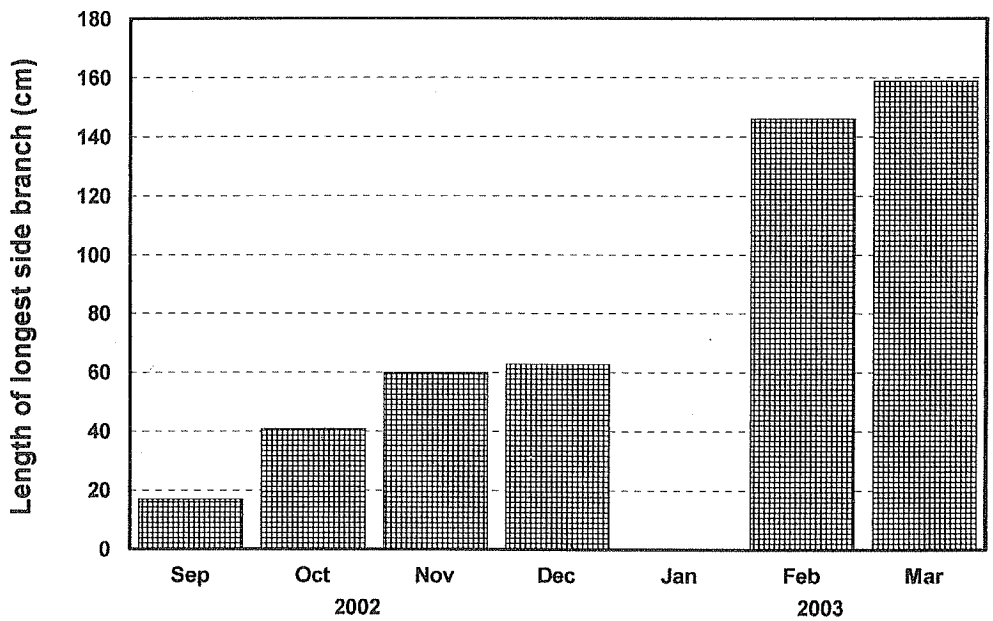

Fig. 2. Length of longest side branch of *Moringa oleifera* in hedgerows
St. Croix, U.S. Virgin Islands

Total dry biomass production from prunings taken seven and ten months after planting averaged 2.06 kg/plant (Table 1). Data in Table 1 also indicates that *Moringa oleifera* is a fast growing tree that attains a height of 2-3 m within one year of growth. This result is consistent with those observed in on-farm trial where *Moringa* attained a height of 4 m six months after planting[12].

Growth and yield of basil are presented in Table 2 for the first harvest and Table 3 for the second harvest. As shown in Table 2, the effect of hedgerow on plant height and plant dry weight was not significant during the first harvest. However, plant fresh weight was significantly influenced by row. There was a tendency for plant fresh weight to be higher in rows adjacent to hedgerows compared to inner rows (Table 2).

This would indicate that at the early stage of hedgerow development, there is no competition effect. During the second harvest, the effect of hedgerow on plant fresh and dry weights was significant (Table 3). There was also a significant interaction between hedgerow and plant row. Mean plant fresh and dry weight were lower in hedgerow than no hedgerow treatment. This suggests that competition by *Moringa* hedgerows becomes apparent in subsequent harvests.

With lemongrass, the competition effect was not significant in the first harvest, which is similar to that of basil (Table 4). In fact, plant fresh and dry weights were slightly higher in hedgerow than no hedgerow treatment. The yield reducing effect by Moringa hedgerows became apparent in subsequent harvests (harvests 2 to 4). Plant fresh weight was significantly reduced in hedgerow intercropping (Tables 5-7). Although the effect of hedgerow treatment was not significant on plant dry weight, data showed that mean dry weight from hedgerow intercropping was lower than the control treatment (no hedgerow) in subsequent harvests.

Table 1. Plant height and biomass of *Moringa oleifera* grown in hedgerows six months after planting. St. Croix, Virgin Islands, 2002-2003.

Pruning date	Plant ht. (cm)	Plant f.w. (kg)	Leaf f.w. (kg)	Total plant f.w. (kg)
19 Dec 2002	262	1.11	0.64	0.28
19 Mar 2003	336	**5.28**	**2.13**	**1.78**
Total		6.39	2.77	2.06

Table 2. Growth and yield of basil in alleys between *Moringa* hedgerows. St. Croix, Virgin Islands, 2002-2003. Data from first harvest.

Treatment	Row	Plant ht. (cm)	Plant f.w. (kg)	Plant d.w. (kg)
Hedgerow	1	56	551	94
	2	59	519	66
	3	55	635	58
	4	57	525	44
	5	48	534	91
	6	53	645	85
	Mean	**55**	**568**	**73**
No hedgerow	1	56	578	82
	2	50	509	84
	3	56	504	84
	4	41	448	78
	5	55	453	71
	6	41	618	46
	Mean	**50**	**518**	**74**
Pr>F				
Treatment		NS	NS	NS
Row		NS	P<0.01	NS
Treatment x Row		NS	NS	NS

NS = not significant

Table 3. Growth and yield of basil in alleys between *Moringa* hedgerows. St. Croix, Virgin Islands, 2002-2003. Data from second harvest.

Treatment	Row	Plant ht. (cm)	Plant f.w. (kg)	Plant d.w. (kg)
Hedgerow	1	47	168	40
	2	52	150	41
	3	61	217	69
	4	59	295	56
	5	45	111	51
	6	47	102	32
	Mean	**52**	**174**	**48**
No hedgerow	1	52	269	57
	2	53	259	57
	3	55	345	66
	4	45	280	76
	5	54	202	69
	6	57	394	111
	Mean	**53**	**291**	**73**
Pr>F				
Treatment		NS	P<0.01	P<0.01
Row		NS	NS	NS
Treatment x Row		NS	NS	P<0.05

Table 4. Growth and yield of lemongrass in alleys between *Moringa* hedgerows. St. Croix, Virgin Islands, 2002-2003. Data from first harvest.

Treatment	Row	Plant ht. (cm)	Plant f.w. (kg)	Plant d.w. (kg)
Hedgerow	1	138	333	120
	2	139	358	96
	3	135	446	113
	4	138	356	130
	5	139	306	80
	6	139	421	99
	Mean	**138**	**370**	**106**
No hedgerow	1	138	360	163
	2	126	279	61
	3	141	398	116
	4	133	356	96
	5	140	330	94
	6	138	358	79
	Mean	**136**	**347**	**101**
Pr>F				
Treatment		NS	NS	NS
Row		NS	NS	NS
Treatment x Row		NS	NS	NS

Table 5. Growth and yield of lemongrass in alleys between *Moringa* hedgerows. St. Croix, Virgin Islands, 2002-2003. Data from second harvest.

Treatment	Row	Plant ht. (cm)	Plant f.w. (kg)	Plant d.w. (kg)
Hedgerow	1	114	329	114
	2	128	262	114
	3	123	290	76
	4	137	374	131
	5	120	223	55
	6	118	198	83
	Mean	**123**	**279**	**95**
No hedgerow	1	123	435	116
	2	114	332	88
	3	127	418	97
	4	108	325	114
	5	117	357	117
	6	131	418	119
	Mean	**120**	**381**	**108**
Pr>F				
Treatment		NS	P<0.01	NS
Row		NS	NS	NS
Treatment x Row		NS	NS	NS

Table 6. Growth and yield of lemongrass in alleys between *Moringa* hedgerows. St. Croix, Virgin Islands, 2002-2003. Data from third harvest.

Treatment	Row	Plant ht. (cm)	Plant f.w. (kg)	Plant d.w. (kg)
Hedgerow	1	88	214	81
	2	91	178	52
	3	77	166	41
	4	96	188	82
	5	86	196	44
	6	89	191	54
	Mean	**88**	**190**	**59**
No hedgerow	1	87	345	76
	2	74	224	44
	3	87	332	60
	4	82	218	63
	5	83	226	57
	6	89	341	101
	Mean	**84**	**281**	**67**
Pr>F				
Treatment		NS	P<0.01	NS
Row		NS	NS	P<0.01
Treatment x Row		NS	NS	NS

Table 7. Growth and yield of lemongrass in alleys between *Moringa* hedgerows. St. Croix, Virgin Islands, 2002-2003. Data from fourth harvest

Treatment	Row	Plant ht. (cm)	Plant f.w. (kg)	Plant d.w. (kg)
Hedgerow	1	81	350	68
	2	98	228	62
	3	92	225	55
	4	102	237	70
	5	107	275	61
	6	103	286	67
	Mean	**97**	**267**	**64**
No hedgerow	1	95	595	69
	2	68	335	26
	3	92	541	51
	4	93	393	92
	5	107	446	76
	6	119	448	96
	Mean	**96**	**460**	**68**
Pr>F				
Treatment		NS	P<0.01	NS
Row		P<0.05	NS	NS
Treatment x Row		NS	NS	NS

Table 8. Photosynthetic active radiation (PAR) in medicinal plant canopy as influenced by Moringa hedgerows in alley cropping systems. St. Croix, Virgin Islands, 2002-2003.

Treatment Crop	PPF1[a]	PPF2[b]	PPF3[c]	Percent reduction	
		μ mole m^{-2} s^{-1}		PPF1	PPF2
19 Dec 2002					
Hedgerow					
Basil	181	626	1571	88	60
Lemongrass	177	241	1298	86	81
No hedgerow					
Basil		405	1101		63
Lemongrass		827	1424		50
17 Mar 2003					
Hedgerow					
Basil	311	887	1618	81	43
Lemongrass	366	878	1456	74	39
No hedgerow					
Basil		1816	1999		9
Lemongrass		1671	1918		13

Measurements taken between 1000-1100 hours.
PPF = Photosynthetic photon flux - a measure of photosynthetic active radiation (PAR) expressed as umol m^{-2} s^{-1}
[a]PPF1 = above crop canopy in rows adjacent to hedgerow
[b]PPF2 = above crop canopy in middle rows
[c]PPF3 = full sunlight

One of the major factors that influence crop yield in hedgerow intercropping is competition for light. Tree-crop interaction may be positive or negative depending on tree and crop species. During the early stage of tree hedgerow establishment, tree-crop interaction is minimal since the hedgerows do not exhibit dominant role. In this trial, photosynthetic active radiation (PAR) was measured above and below the canopy of medicinal plants grown in alleys within hedgerows of *Moringa*. PAR was reduced greatly in rows adjacent to hedgerows in both measurement dates (19 Dec and 17 Mar, Table 8). PAR was also lower in hedgerow than no hedgerow treatment for both basil and lemongrass. Palada et al., 2003 reported a 21-33% reduction in PAR reaching basil and lemongrass canopy under *Moringa* hedgerows in on-farm trial. In spite of light reduction, yields of these two species were not drastically reduced, indicating that the light compensation point for these species is lower than other species. Because of time limitation, PAR was not determined for other species, however, PAR measurement for Basil and Lemongrass is representative for all hedgerow plots with intercrops. Cost and returns analysis for basil and lemongrass are shown in Tables 9a-b and 10a-b. In general, economic returns were higher for hedgerow intercropping than monoculture Pre-tax returns from intercropping was lower than monoculture for basil and lemongrass. The lower returns from intercropping are mainly due to decreased total yield of herbs in subsequent harvests.

Table 9a. Estimated cost and returns for basil monocrop, St. Croix, 2002-2003.

Basil Monocrop

.025 hectare unit

Item	Unit	Qty.	Price ($)	Amt.
SALES				
Sale of fresh basil from .025 ha	kg	525.2	$20	$10,503
Other sales				$0
Total Revenue				**$10,503**
OPERATING COSTS				
Seedlings	plants	960	$0.15	$144
Fertilizer (20 - 20 - 20)	bags	0.7	$23.60	$16
Herbicide and Insecticides (Azetin™, Dipel™, and Mpede™)	package	1	$245.15	$245
Water	m^3	12	$4.49	$54
Labor: (a) irrigation (set-up & repair)	hrs.	9	$6.25	$58
(b) planting	hrs.	8	$6.25	$50
(c) fertigating and weeding	hrs.	83	$6.25	$521
(d) harvesting (including weighting & bunching)	hrs.	24	$6.25	$150
Machinery: (a) plowing	hectare	0.025	$154.44	$4
(b) harrowing	hectare	0.025	$38.61	$1
(c) tilling	hectare	0.025	$38.61	$1
Interest on operating capital	$	2.00%	577	$12
Total Operating Cost				**$1,256**
FIXED COSTS				
Land lease	hectare	0.025	$49.42	$1
Interest on avg. investment (excl. land)	$	10.00%	1041.67	$104
Depreciation: (a) irrigation equipment	hectare	0.025	$257.40	$6
(b) other equipment	hectare	0.025	$12.87	$0
(c) well	hectare	0.025	$72.08	$2
(d) other	hectare	0.025	$5.15	$0
Total Fixed Cost				**$114**
PRE-TAX RETURNS (total revenue - total operating costs - fixed cost)				**$9,133**
BREAK-EVEN PRICE PER KILOGRAM =				**$2.61**
(at current production level) = ([total fixed costs / kgs sold] + [operating cost per kilogram])				
NET PRESENT VALUE (PRE-TAX) OF A 20-YEAR LEASE UNDER THIS PRODUCTION SYSTEM:				**$113,820**

Assumptions:

1. Total revenue and costs are rounded off to the nearest dollar.
2. Two plantings.

Data source:

1. Input and yield data: UVI-AES experimental plots; production data are for 2002-03
2. Depreciation rates: Previous UVI-CES enterprise budgets
3. Selected costs and prices: VI Dept of Agriculture and previous UVI-CES enterprise budgets
4. Output price: Informal survey of local growers, farmers market and supermarket. Moringa powder price from www search.

Table 9b. Estimated cost and returns for Basil-Moringa intercrop, St. Croix, 2002-03.

Basil - Moringa Intercrop

.025 hectare unit

Item	Unit	Qty.	Price ($)	Amt.
SALES				
Sale of fresh basil from .025 ha	kg	430.6	$20	$8,612
Moringa Powder sales	kg	28.9	$25	$723
Total Revenue				**$9,335**
OPERATING COSTS				
Seedlings	plants	960	$0.15	$144
Fertilizer (20 - 20 - 20)	bags	0.7	$23.60	$16
Herbicide and Insecticides (Azetin™, Dipel™, Mpede™)	package	1	$245.15	$245
Water	m^3	13.5	$4.49	$61
Labor: (a) irrigation (set-up & repair)	hrs.	9	$6.25	$58
(b) planting	hrs.	9	$6.25	$58
(c) fertigating and weeding	hrs.	83	$6.25	$521
(d) harvesting (including weighting & bunching)	hrs.	61	$6.25	$379
Machinery: (a) plowing	hectare	0.025	$154.44	$4
(b) harrowing	hectare	0.025	$38.61	$1
(c) tilling	hectare	0.025	$38.61	$1
Interest on operating capital	$	2.00%	577	$12
Total Operating Cost				**$1,499**
FIXED COSTS				
Land lease	hectare	0.025	$49.42	$1
Interest on avg. investment (excl. land)	$	10.00%	1041.67	$104
Depreciation: (a) irrigation equipment	hectare	0.025	$257.40	$6
(b) other equipment	hectare	0.025	$12.87	$0
(c) well	hectare	0.025	$72.08	$2
(d) other	hectare	0.025	$5.15	$0
Total Fixed Cost				**$114**
PRE-TAX RETURNS (total revenue - total operating costs - fixed cost)				**$7,722**
BREAK-EVEN PRICE PER KILOGRAM (Basil) =				**$3.75**
BREAK-EVEN PRICE PER KILOGRAM (Moringa) =				**$55.74**
(at current production level) = ([total fixed costs / kgs sold] + [operating cost per kilogram])				
NET PRESENT VALUE OF A 20-YEAR LEASE UNDER THIS PRODUCTION SYSTEM:				**$96,403**

Table 10a. Estimated cost and returns for Lemongrass Monocrop.
St. Croix, 2002-2003.025 hectare unit

Item	Unit	Qty.	Price ($)	Amt.
SALES				
Sale of fresh lemongrass from .025 ha	kg	734.4	$20.00	$14,688
Other sales				$0
Total Revenue				**$14,688**
OPERATING COSTS				
Seedlings	plants	480	$0.15	$72
Fertilizer (20 - 20 - 20)	bags	0.7	$23.60	$16
Herbicide and Insecticides (Azatin™, Dipel™, and Mpede™)	pkg	1	$245.15	$245
Water	m^3	12	$4.49	$54
Labor: (a) irrigation (set-up & repair)	hrs.	9	$6.25	$58
(b) planting	hrs.	4	$6.25	$25
(c) fertigating and weeding	hrs.	83	$6.25	$521
(d) harvesting (including weighting & bunching)	hrs.	32	$6.25	$200
Machinery: (a) plowing	ha	0.025	$154.44	$4
(b) harrowing	ha	0.025	$38.61	$1
(c) tilling	ha	0.025	$38.61	$1
Interest on operating capital	$	2.00%	577	$12
Total Operating Cost				**$1,209**
FIXED COSTS				
Land lease	ha	0.025	$49.42	$1
Interest on avg. investment (excl. land)	$	10.00%	1041.67	$104
Depreciation: (a) irrigation equipment	ha	0.025	$257.40	$6
(b) other equipment	ha	0.025	$12.87	$0
(c) well	ha	0.025	$72.08	$2
(d) other	ha	0.025	$5.15	$0
Total Fixed Cost				**$114**
PRE-TAX RETURNS (total revenue - total operating costs - fixed cost)				**$13,365**
BREAK-EVEN PRICE PER KILOGRAM =				**$1.80**
(at current production level) = ([total fixed costs / kgs sold] + [operating cost per kilogram])				
NET PRESENT VALUE OF A 20-YEAR LEASE UNDER THIS PRODUCTION SYSTEM:				**$167,732**

Assumptions:

1. Total revenue and costs are rounded off to the nearest dollar.
2. Replanting not required due to natural regeneration.

Data Source:

1. Input and yield data: UVI-AES experimental plots; production data are for 2002/2003.
2. Depreciation rates: Previous UVI-CES enterprise budgets.
3. Selected costs and prices: VI Dept. of Agriculture and previous UVI-CES enterprise budgets.
4. Output price: Informal survey of local growers, farmers market and supermarket. Moringa powder price feom www. search

Table 10b. Cost and returns for Lemongrass - Moringa Intercrop.
St. Croix, 2002-2003 .025 hectare unit

Item	Unit	Qty.	Price ($)	Amt.
SALES				
Sale of fresh lemongrass from .025 ha	kg	559.7	$20	$11,194
Moringa Powder sales	kg	28.9	$25	$723
Total Revenue				**$11,917**
OPERATING COSTS				
Seedlings	plants	480	$0.15	$72
Fertilizer (20 - 20 - 20)	bags	0.7	$23.60	$16
Herbicide and Insecticides (Azatin™, Dipel™, and Mpede™)	pkg	1	$245.15	$245
Water	m^3	13.5	$4.49	$61
Labor: (a) irrigation (set-up & repair)	hrs.	9	$6.25	$58
(b) planting	hrs.	5	$6.25	$33
(c) fertigating and weeding	hrs.	83	$6.25	$521
(d) harvesting (including weighting & bunching)	hrs.	69	$6.25	$429
Machinery: (a) plowing	ha	0.025	$154.44	$4
(b) harrowing	ha	0.025	$38.61	$1
(c) tilling	ha	0.025	$38.61	$1
Interest on operating capital	$	2.00%	577	$12
Total Operating Cost				**$1,452**
FIXED COSTS				
Land lease	ha	0.025	$49.42	$1
Interest on avg. investment (excl. land)	$	10.00%	1041.67	$104
Depreciation: (a) irrigation equipment	ha	0.025	$257.40	$6
(b) other equipment	ha	0.025	$12.87	$0
(c) well	ha	0.025	$72.08	$2
(d) other	ha	0.025	$5.15	$0
Total Fixed Cost				**$114**
PRE-TAX RETURNS (total revenue - total operating costs - fixed cost)				**$10,351**
BREAK-EVEN PRICE PER KILOGRAM (Inflammation Bush) =				**$2.80**
BREAK-EVEN PRICE PER KILOGRAM (Moringa) =				**$54.12**
(at current production level) = ([total fixed costs / kgs sold] + [operating cost per kilogram])				
NET PRESENT VALUE OF A 20-YEAR LEASE UNDER THIS PRODUCTION SYSTEM:				**$130,338**

Summary and Conclusion

This initial study indicates that integration of medicinal plants and culinary herbs into agroforestry systems involving medicinal trees is feasible in water-limited environment such as the Caribbean. Traditional medicinal plants including Lemongrass, Blue Verbena, Inflammation Bush, and Japana as well as some culinary herbs such as Basil, Thyme, Sweet Marjoram, Cilantro, Chive and Mint can be grown in alleys formed by hedgerows of medicinal tree *Moringa* with minimal negative effect on growth and yield. Competition for light was not critical at the early establishment period of hedgerows. Additional studies are needed to determine the long-term effect of tree-crop interaction on total productivity of this system in the tropics.

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