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TECHNICAL MANUAL

FOR THE PRODUCTION OF SPECIFIC HERBAL PLANTS IN JAMAICA

August 2015

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FOR THE PRODUCTION OF SPECIFIC HERBAL PLANTS IN JAMAICA

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Introduction

With increased international awareness of healthy lifestyle choices, consumers are vying for safe, healthy and nutritious foods (Smith, 1993). To meet this growing demand, producers are shifting their focus to the cultivation of herbal crops. These herbal crops are being utilized in the nutraceutical, pharmaceutical, culinary and beverage industries to produce many products (Leite *et al.,* 1986). This interest in the growing of herbal crops was strongly expressed by regional representatives during the meeting and follow-up activities of the Caribbean Herbs Business Forum Montego Bay, Jamaica, December 2002 (CARDI, 2009). During the deliberations at the technical sessions of this conference, it was generally agreed that a major constraint to the development of a regional medicinal-plant farming sector is the lack of technical information for the commercial production of medical herbs.

Historically, herbs or herbaceous plants have been grown around the world for both their culinary, enhancing taste and fragrance as well as for their beneficial medicinal properties. In the Caribbean, there is an abundance of native herbs which are in use for their flavour or medicinal properties. The unique flavour of the Jamaican jerk is testimony to the use of native herbs and spices to make unique blends of seasonings for native foods. Similarly, in Trinidad, the use of the native shadon beni (*Eryngium foetidum* L.) adds a distinctive and exotic flavour to Trinidadian foods.

In several Caribbean countries, there is also a rich history of ethnomedicine (Williams, 2006). Medicinal plants have been closely associated with the traditional, social and cultural events of the people in the Caribbean. Medicinal plants are commonly referred to in folk medicine or bush medicine in the Region. Many myths and legends are associated with some of these herbs and medicinal plants which are in use. In Jamaica, legend has it that the spirit weed, when picked during certain phases of the moon, has the power to make the person who chews the root invisible. The Maroons of Jamaica used it against the British during their resistance, and reports from British soldiers state that they could not see the enemy. So they threw away their weapons and ran back to their camps with reports that the trees were fighting them, because they could see leaves moving and hear the rustling but could see no one (Henry and Harris, 2002).

Currently there is a growing demand for herbal products, spices and functional foods both Regionally and Internationally. The recent trend towards wellness and healthy eating habits has seen the promotion of the use of spices to compensate for less salt and lower fat levels in foods. With the explosion and fusion of ethnic cuisine from Asia and Latin America and the Caribbean, this trend has served to not only sustain the herbs and spice trade but incrementally increase it.

The USA remains the world's largest spice importer, meeting 60% of its total needs from outside sources. According to FAOSTAT data (Food and Agriculture Organization, 2007), the EU market for spices and herbs increased from 221,000 tonnes in 2000 to 310,000 tonnes in 2004, representing an average annual increase of 9%. Globally, the leading spices consumed are pepper, paprika and allspice (pimento), while leading herbs include thyme and oregano.

Spices and herbs are sold to three main end-users: the industrial, retail and catering sectors (CBI, 2007). In addition to the culinary market sector, there is also the medicinal (including supplements)

and the essential oils market (Export Centre and Business Information Point and the Jamaica Exporters Association, 2008). In almost all EU countries, the industrial sector consumes the largest proportion, accounting for 55-60% of the total usage of spices and herbs. The retail sector consumes 35-40% and the catering sector 10-15%.

Nutraceuticals and functional foods emerged almost two decades ago as lucrative options for tapping the healthy lifestyle niche market. Steady growth in the global market for nutraceuticals which includes foods, beverages and supplements, worth US$117.3 billion in 2007 is expected to increase to $176.7 billion in 2013 (BCC Research, 2008). The markets for nutraceuticals and dried spices and herbs present excellent opportunities for product diversification in the Caribbean.

An essential pillar to the realisation of this product diversification is the development of agronomic techniques for cultivating these plants so that production can be more easily managed and organised to meet the growing market needs. There is a cultural familiarity with these plants and they are often found in abundance in the wild (2003). This has to be built on to provide information on improved species and cultivars along with recommended crop management practices for increasing yield and economic returns. At the present time there is paucity of information and published material with complete descriptions and methodologies for sustainable production for Caribbean herbal crops.

As a consequence, the main focus of this manual is to deliver technical packages for the commercial production of selected herbal species. The plant species selected were blackmint (*Mentha spicata, syn M. vividis*), cerasee (*Momordica charantia L*), grass (*Cymbopogan spp*.), peppermint (*Satureja vimenea*) sorrel (*Hibiscus sabdariffa*) which are used in the nutraceutical, pharmaceutical, culinary and beverage industries based on their essential oils and secondary metabolites.

A set of agronomic practices was developed from the literature and using our own initiative and experience where no information was available. The bibliography contains the articles that were referenced when developing the set of agronomic practices from the literature. Successful cultivation was taken as being able to establish the crop and achieve an "economically" acceptable yield. During the process of establishment, growth parameters were measured and observations were made on pest and diseases and these were also recorded.

Demonstration plots of the selected plant species were first established on the CARDI Demonstration and Training Centre (DTC) at Mona. Under this better supervised arrangement important data were collected, such as plant establishment, rate of growth, time to 50% flowering, time to fruit maturity/harvesting and yield. In addition, a better and closer look at the growing habits, nutritional requirements and pest and disease incidences of these plants was made at the DTC.

Using this process, a set of agronomic practices was developed and is here being recommended for the growing of lemon grass, cerasee and sorrel in Jamaica. These practices relate to the soil and climatic conditions of the Mona DTC, but they can be adapted to provide useful information on the production of these plant species in other parts of Jamaica and the Caribbean. Under the soil

and climatic conditions at the Mona DTC it was not possible to establish plots and obtain an acceptable yield for the other two plant species, peppermint and blackmint.

It was therefore decided to establish plots of these crops at the Sam Motta DTC in Knock Patrick, Manchester. Although this area tends to be drier the soil is less acidic and loose; the maximum and minimum temperatures are also lower than that at the Mona DTC. Under these conditions, peppermint and blackmint plants performed much better and more acceptable yields of the products were obtained.

This manual sets out the practices which have been carried out by researchers to successfully grow the plant species blackmint, cerasee, lemon grass, peppermint and sorrel in monoculture to produce acceptable yields either at the Mona or Sam Motta DTCs of the CARDI Jamaica unit.

1. Nursery operations and plantlet/seedling production

The propagation of herb plantlets in the nursery is no different to the propagation of other crop species. Care must be taken to ensure that the young cuttings or small emerging seedlings have the best soil, moisture and heat conditions to promote plant growth. In this regard, the temperature in the Caribbean is usually ideal for crop growth throughout the year. The soil and water conditions are therefore the main factors to be considered in the nursery operation.

1.1 Soil preparation

The soil mixture to be used for the propagation of the plants should crumble easily and be without clods, stones or large pieces of plant debris. The mixture should have organic materials to hold water e.g., peat moss, compost and coarse textured inorganic materials for air space and drainage e.g., sand, perlite, vermiculite. Nutrients will be obtained from the organic material and this can be supplemented by adding inorganic fertilizers.

In many cases the soil mixture is made by including soil from the field with commercial organic material e.g. vermi-compost. If soil from the field is being used it must be sterilized to destroy any detrimental fungi, bacteria and insects in the soil. This ensures that seedlings do not succumb to damping off, and other life-ending diseases that plague seedlings and plantlets grown in un-sterile potting mix.

There are various methods available for sterilizing soil to be used as potting mix. Four of these are:

1. **Oven method**- Spread soil not more than 10 cm deep in non-plastic containers, such as seed flats, clay pots and glass or metal baking pans. Cover each container tightly with aluminum foil. Set the oven between 82^{o}C – 93^{o}C. Heat the soil to at least 82^{o}C; keep at this temperature for 30 minutes.
2. **Microwave oven method**-Microwave soil for 90 seconds per kilogram on full power. Don't use metal containers and aluminum foil when using a microwave.
3. **Pressure cooker method**- Pour several cups of water into the cooker filling it at least half way. On a rack above the water, place shallow pans containing no more than 10 cm of soil. Level the soil, but do not pack it down. Cover each container with aluminum foil. Stack the containers to allow steam circulation. Close the lid, but leave the steam valve open somewhat until all the air is forced out and steam begins to escape. Then close the steam valve and heat at 10 pounds pressure for 15 minutes.
4. **Steam sterilization without pressure**- Pour about 3 cm of water into the sterilizing container. Follow the soil preparation procedures for the pressure cooker method. Place filled containers on a rack to keep them out of the water. Close the lid and bring the water to a boil. Open the lid just enough to prevent pressure build-up. When steam begins to escape, continue boiling for 30 minutes.

At the Mona DTC, an open pan method of soil sterilization is practiced. In this method a flat pan approximately 2 m in diameter is filled with loose topsoil and heated over an open wood fire. The soil is continually turned to ensure proper heat distribution (Plate 1.1). Water is then added directly to the soil to provide the steam for sterilization

Plate 1.1. An open pan method of soil sterilization which is practiced at the Mona DTC

Compost can be a very important component in the potting mix as it:

- provides plant nutrients,
- increases soil water and nutrient retention in the mixture,
- increases drainage and reduces the possibility of puddling in the container,
- enhances nutrient uptake from the soil mixture,
- promotes healthy root development resulting in enhanced seedling and plantlet development.

1.2 Propagation of the five herbal species in the nursery

1.2.1 Blackmint

Blackmint plants were propagated by stem cuttings. Blackmint is a runner and puts down roots at every node as it spreads across the soil surface. Each node of the stem can therefore be used as a cutting for plant propagation. Cuttings of two to three nodes were placed in sandboxes and watered on a daily basis to facilitate rooting. Rooting occurred within 1 month. The rooted cuttings were then transferred to 1 litre cups or bags to provide more root room and to facilitate the movement of plantlets into the field at the time of transplanting. In the smaller container the rooted cuttings are watered two to three times per week, or as often as required, as blackmint strives best under very wet soil conditions. Under these conditions, the cuttings quickly begin to produce leaves and after about 6 - 8 weeks they can be transplanted into the field.

Plate 1.2. Blackmint cuttings planted into plant pots and sand boxes

Plate 1.3. Blackmint plantlets ready for transplant

1.2.2 Cerasee

Cerasee seedlings were propagated in the nursery before transplanting. The cerasee fruit produces a set of seeds which are coated in a red aril when ripe. These seeds are collected and dried. The aril is stripped away before or after drying. Dried seeds are then sown into a container (seed tray, cups, bags etc) with potting mix. The container is watered regularly to facilitate germination. Germination occurs within 2 weeks and seedlings can be transferred to the field in another 2 weeks.

Plate 1.4. Cerasee seeds in the fruit

Plate 1.5. Cerasee seedlings ready for transplanting

1.2.3 Lemon grass

Lemon grass was propagated by tillers. Some lemon grass species produce seeds but these seeds were not found to be viable in Jamaica. Planting material is produced by digging up the lemon grass stool from the root and separating the clump into individual tillers. Each tiller is then set into a container of loose draining soil and watered every 2 - 3 days to allow root development. If the tiller has long leaves these are normally cut back to reduce transpiration and water loss during the initial rooting stage. Tillers develop sufficient roots to allow transplanting in about 6 weeks.

Conversely if there are many stools available, they can be separated into clumps of four to six tillers and planted directly into the field. In the absence of rain, irrigation will be necessary to ensure these transplants develop new roots.

Plate 1.6. Lemongrass stool ready for separating into individual tillers

Plate 1.7. Lemon grass tillers planted into sand box for initial rooting

Plate 1.8. Lemon grass tillers planted into Styrofoam cups for growth and hardening

Plate 1.9. Lemon grass plantlets in Styrofoam cups ready for transplanting

1.2.4 Peppermint

Peppermint plants were propagated by stem cuttings. Soft green areas of stem of about 10 cm in length were selected. Stem cuttings were placed in sandboxes and watered on a daily basis to facilitate rooting. Rooting occurred within 3 weeks and rooted plantlets were transplanted into individual containers (1 litre cups, bags) with loose potting mixture for growth and hardening.

Plants were watered every 3 days. Care was taken to ensure the soil was never saturated as peppermint cannot tolerate waterlogging. Under the nursery conditions, plantlets can take between 2 – 4 months to grow into a suitable size and hardiness for transplanting. They are then transplanted into the field to a depth of 15 cm.

Plate 1.10. Peppermint cuttings planted into sand box

Plate 1.11. Peppermint plantlets in cups showing the effects of waterlogging

1.2.5 Sorrel

The sorrel plant produces seeds which are planted directly into the soil. Seeds can also be sown in the nursery to produce seedlings which are then transplanted into the field. But the roots are very sensitive and can dieback due to shock at such a small stage. Also, transplanted seedlings appear to be more susceptible to soil borne diseases. It is therefore best to collect seeds from mature fruits, dry thoroughly and then sow seeds directly in the field. Irrigation should be carried out on a regular basis to ensure adequate soil moisture. Germination will occur within 1 week of planting.

Plate 1.12. Sorrel seeds in capsule before drying

Plate 1.13. Dried sorrel seeds

2. BLACKMINT

Family: Lamiaceae (Labiatae)

Botanical name: *Mentha spicata*, syn M. *vividis*
Popular names: Blackmint, spearmint
Part Used: Leaf

2.1 History
Mentha is listed in the Icelandic pharmacopoeias of the 13th century. The Greeks and Romans crowned themselves with mentha at feasts and adorned tables with sprays of leaves while the cooks used them to flavour sauces and wines. It is thought to have come into general use in the medicine of Western Europe in the mid-18th century as blackmint was grown commercially for its oil as early as 1750.

Mentha is now grown throughout the world. There are both blackmint, which has violet coloured leaves and stems and a high volatile oil content, and whitemint, with green leaves and stems with a much milder taste.

2.2 Origin and geographic distribution
Blackmint or spearmint is a species of mint probably native to much of Europe and southwest Asia, though its exact natural range is uncertain due to extensive early cultivation.

2.3 Botany
It is a herbaceous rhizomatous perennial plant, growing up to 50 cm tall, with variably hairless to hairy stems and foliage, quadrangular stems which terminate in a flower spike composed of whorls. It has a fleshy underground rhizome which spreads widely just below the soil surface and from which the stems and leaves develop. The leaves have short petioles, are opposite, ovate to lanceolate with serrated edges. They are also rough textured and slightly paler in colour on the underside of the leaf.

2.4 Nutrition content and uses
The active constituents of blackmint are listed as:
caffeic acid (rosmarinic acid), flavonoids (apigenine-, diosmetin-, luteolin glycosides, free lipophile methoxylized flavone <xanthomicrol, gardenineD>), volatile oil (alpha- and beta-pinene, isomenthone, limonene, menthofurane, menthol, menthone, menthyl acetate, neomenthol, pulgeone, transabinene hydrate).

Mint tea is usually made from blackmint. The leaves can either be used on their own or dried and mixed with ordinary tea. The volatile oils and flavonoids give mentha its anti-inflammatory, anti-microbial and smooth muscle relaxing abilities.

The oil is used medicinally to relieve sickness and nausea and its strong flavour and smell mean that it is widely used to disguise the more unpleasant taste of other drugs.

Blackmint also has culinary use in mint sauce, mint jelly, and juleps, a sweet mint drink. It can also be used to make jams and flavouring in confectionary. The world renowned spearmint chewing gum is flavoured by a variety of blackmint mint called spearmint. It is thought to be an aid to digestion.

The mojito is a traditional Cuban highball which has mint leaves as part of its recipe. Traditionally, a mojito is a cocktail that consists of five ingredients: white rum, sugar (traditionally sugar cane juice), lime juice, sparkling water and mint. The original Cuban recipe uses spearmint or *yerba buena*, a mint variety very popular on the island. Its combination of sweetness, refreshing citrus and mint flavors are intended to complement the potent kick of the rum, and have made this clear highball a popular summer drink.

Plate 2.1. Traditional Cuban mojito

2.5 Agronomy of blackmint

2.5.1

The mentha group has several species and hybrids/cultivars with unique foliage, flowering and growth patterns. With respect to blackmint (*Mentha spicata syn M. vividis*), there is also a whitemint with similar properties. Blackmint develops with a tinge of purple pigmentation in the stems and the leaves giving a black appearance; whitemint however has only green pigmentation. The concentration of essential oil is said to be greater in blackmint; however the whitemint has superior potency of menthol.

Plate2.2. Blackmint

Plate 2.3. Whitemint

2.5.2 Land preparation

Blackmint will grow in a wide range of soil types such as sand, loam, clay, and organic/peat but is shallow-rooted and needs a friable soil that retains moisture well. It is best suited to moist

conditions, but can also grow under dry conditions if kept adequately cool. Dry areas should therefore be shady. Soil pH should be 5.0 – 6.5. In heavy soils, there needs to be proper soil tillage to ensure the soil is well aerated and loose enough to permit root penetration. The soil should be ploughed and refined to a depth of at least 20 cm as most planting is done into holes 15-20 cm in depth.

Due to a preference for high moisture content, blackmint needs to be planted in areas with high and continuous rainfall. If rainfall is low and the soil has good moisture retention properties, plants can be set in either shallow holes or in furrows. Shallow holes are spaced 1 m apart, centre-to-centre, with a diameter of 0.5 m and a depth of 15 cm with gentle slopes. Furrows are built 1 m apart for each row with gentle slopes with a depth of about 0.3 m.

Plate 2.4. Blackmint plantlets growing in sink holes at the Mona DTC

2.5.3 In field planting

Blackmint needs a plentiful supply of water for growth, so the crop should be planted to coincide with the rainy seasons. In the Caribbean this is normally May through December. If rainfall is limited, irrigation will be necessary for the plant to be established.

In heavy soils, rooted plantlets are planted into the prepared furrows or plant holes at a spacing of 1 m x 1 m. They are planted 5 – 10 cm deep. In lighter soils, furrows may not be necessary and plantlets can be planted with the same spacing without the preparation of shallow holes or furrows.

Under ideal conditions plants will establish themselves and begin growing within 2 weeks of transplanting into the field.

2.5.4 Growing habit

Blackmint is a plant which grows along the ground, and can develop roots along the stem so that after time it covers the ground. The more meaningful measure of plant growth is therefore the perpendicular width measurements which note the spread of the plant over time. Figure 2.1 shows

the growth parameter measurements for blackmint grown at the Mona DTC. When measurements were initiated at 15 weeks after transplanting (WAT), blackmint plants had covered a mean width of approximately 80 cm. This mean width steadily increased to about 110 cm over the next 7 weeks. At about 110 cm width, the blackmint had covered the inter plant spacing and therefore maintained this width for another 20 weeks. During this period the blackmint crop is normally harvested. Portions of the plant which are not attached to the soil are harvested to reduce possible contamination, and also to not hinder plant growth.

The part of the graph from 35 WAT to 45 WAT indicates a period of dieback due to low rainfall conditions and weed infestation which was corrected by irrigation and weeding. This treatment resulted in a second cycle of plant growth and harvesting.

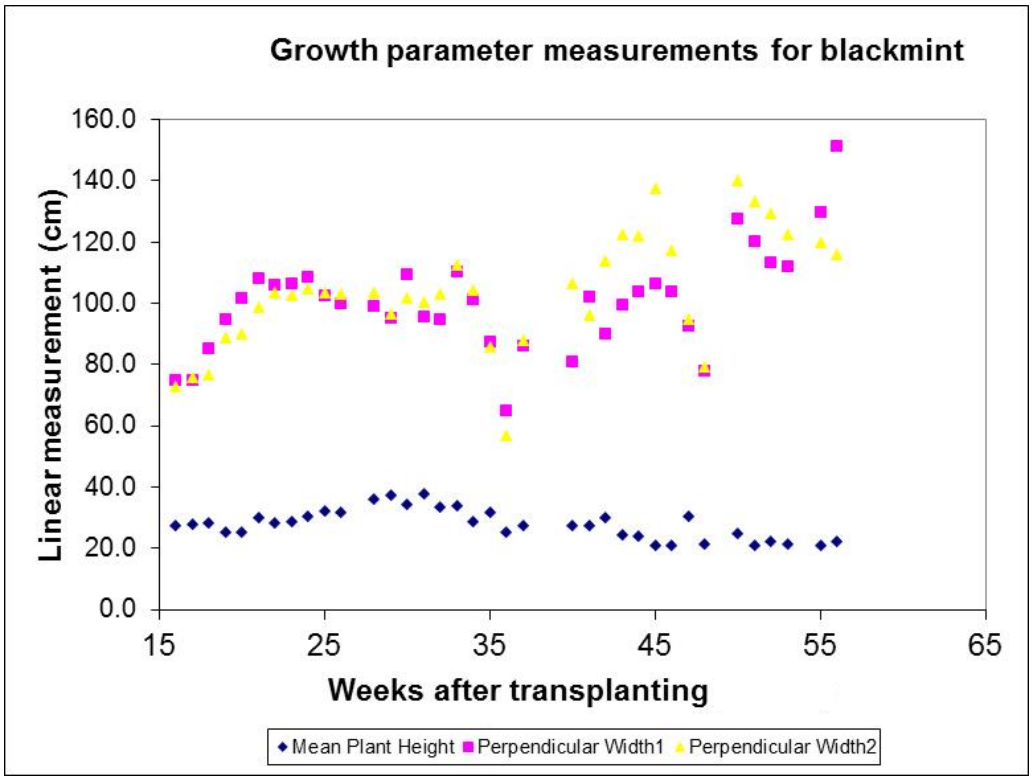

Figure 2.1 Growth parameter measurements taken for blackmint

Plate 2.5. Early growth of blackmint at Sam Motta DTC under dry conditions and no irrigation

Plate 2.6. Growth of blackmint at Mona DTC under irrigation

2.5.5 Cultural practices

Weed control

Blackmint is a creeping plant and will quickly spread over the surface of the plot and exclude weeds. If growth is slow, manual weeding will be necessary to manage the spread of weeds within the plots. Weeding along the walkway and around the plots is also an important sanitary method and can help to prevent the spread of weeds into the plot. This can also help reduce pest incidence. During the dry season it is noted there is likely to be more weed infestation as the plants will reduce their normal prolific growth.

Nutrient management

There is no record of synthetic fertilizer use in blackmint production in the region. Fertilizing with synthetic nitrogen is however likely to enhance growth and leaf yield. In the plots at Mona and Sam Motta, organic manure at the rate of 0.5 kg into each planting hole (5,000 kg/ha) was applied. At Mona DTC cow manure was used while at Sam Motta vermi-compost, made from goat dung, was used.

Irrigation

In the absence of adequate rainfall, plants will need to be irrigated on a regular basis to ensure adequate growth and development. The use of drip irrigation is recommended as it is acquiring general acceptance in the Caribbean; this regulates the amount of water which is dispensed to each plant root and uses a smaller amount of water compared to other irrigation methods. The growth of blackmint is also thought to be affected by ambient temperature as even with adequate irrigation the blackmint plants showed serious dieback during the hot, dry times of the year at the Mona DTC. There is less dieback of plants in the cooler climate at the Sam Motta DTC. Overall, this crop is very sensitive to soil moisture and any drying of the soil causes dieback. It appears to be more suitable to wet soil conditions, normally found in low-lying, swampy areas.

Plate 2.7. Blackmint plants showing dieback during the dry season at Mona DTC

Plate 2.8. Blackmint plants excellent growth at the Sam Motta DTC

Pest and disease management

The Eight-spotted Flea Beetle (*Omophoita cyanipennis*) is the main pest which feeds on the leaves of blackmint and causes "bullet-hole" damage on the leaves of the plant.

Managing the Eight-spotted Flea Beetle without the use of pesticides involves intercepting the life cycle of the beetle. The adults feed above ground on the foliage while the nymphs hatch and feed underground on plant roots. Mulching or polycropping the bare earth sections in and around the plot prevents the adult beetles from laying eggs, and also emerging nymphs will be hindered from exiting underground, so the population of beetles is reduced.

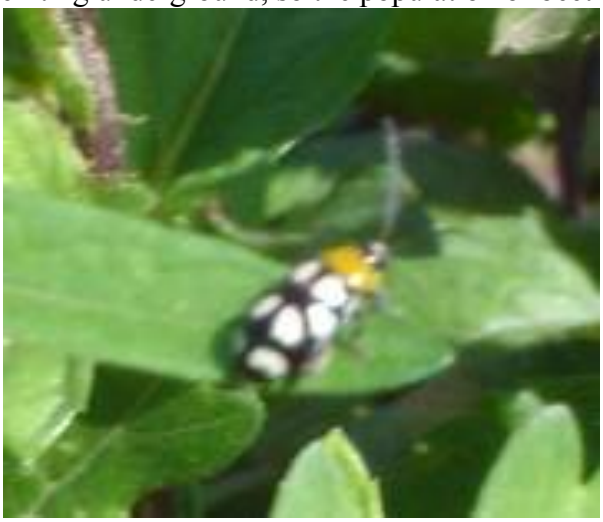

Plate 2.9. Eight-spotted Flea Beetle adult

2.6 Harvesting

Under good growing conditions, blackmint can be harvested for the first time 4 - 5 months after transplanting. This period is necessary to allow the mint to grow out and establish itself in the plot. In the rainy season or under irrigation the plants can then be harvested every 4 - 6 weeks.

Harvesting is done by cutting the nodes which are growing vertically, selecting the younger stem areas that have not hardened with barks. Stems should be cut at an even height distribution of about 15 cm from the ground. From the harvest data obtained from the Sam Motta DTC, fresh weight yields of leaves and stems of blackmint were calculated at 1.2 tonnes per hectare (0.5 tons per acre).

Plate 2.10. Harvesting blackmint at Sam Motta DTC

2.7 Postharvest handling

Harvested stems and leaves must be washed thoroughly with 5% bleach solution to remove any residue of soil or other contaminants coming from the field. Excess water is allowed to drain away from the stems and leaves which are then placed either in paper bags or on trays lined with mesh netting for drying. Solar drying is recommended where there is an abundance of sunlight. Drying in direct sunlight is not recommended as this may cause leaves to become discoloured.

With small amounts of blackmint, paper-bags are suitable as they allow for more manageable sub-units. Set 0.25 kg of black mint cuttings per large paper bag, spreading the cuttings evenly around the sides of the bag. For larger amounts, it is necessary to spread the cuttings on a mesh lined tray so as to maximize the usage of space, allowing air circulation and uniform drying. Spread the cuttings evenly to a maximum thickness of about 5 cm. Whether drying in paper-bags or trays, turn the cuttings daily to allow even drying and prevent mould build up. After a week of solar drying, weight loss due to water loss from the harvest is expected to reach about 70%. The calculated dried weight yield of blackmint is 300 kg/ha .

3. CERASEE

Family: Cucurbitaceae
Botanical name: *Momordica charantia* L
Popular names: Cerasee, caraille, carilla
Part Used: Leaf, fruit

3.1 History
Momordica is a Latin word that means "to bite" and refers to the look of the uneven seeds. The species name *charantia* is unclear as to meaning but could be Latin and refer to the pointed fruit.

3.2 Origin and geographic distribution
Cerasee is a tropical plant, but its original native range is unknown. It is a tropical and subtropical vine, widely grown in Asia, Africa, and the Caribbean for its edible fruit, which is among the most bitter of all fruits, commonly referred to as bitter melon. There are many varieties that differ substantially in the shape and bitterness of the fruit.

3.3 Botany
Cerasee is an herbaceous, tendril-bearing climbing vine which is commonly seen growing on walls, fences and shrubs in the tropics. It bears simple, alternate leaves 4 – 12 cm across, with three to seven deeply separated lobes. Each plant bears separate yellow male and female flowers.

The fruit has a distinct warty exterior and an oblong shape. It is hollow in cross-section, with a relatively thin layer of flesh surrounding a central seed cavity filled with large flat seeds and pith. The fruit is most often eaten green, or as it is when beginning to turn yellow. At this stage, the fruit's flesh is crunchy and watery in texture, similar to cucumber, chayote or green bell pepper, but it is more bitter. The skin is tender and edible. Seeds and aril appear white in unripe fruits; they are not intensely bitter and can be removed before cooking.

As the fruit ripens, the flesh becomes tougher, more bitter, and too distasteful to eat. On the other hand, the aril becomes sweet and intensely red; it can be eaten uncooked in this state, and is a popular ingredient in some Southeast Asian salads.

When the fruit is fully ripe it turns orange and mushy, and splits into segments which curl back dramatically to expose seeds covered in bright red aril (**See Plate 1.4**).

3.4 Nutrition content and uses
Active ingredients are:
Aerial parts -- flavanoids, saponocides, phenols, tannins, alkaloids, steroids, terpinoids-momordicinas 1,2,3, quinines.
Fruits -- amino acids alanine, beta alanine, gamma alanine, gamma-amino-butiric acid, glutamic acid, prolin, tryptamine, p-polypetides, steroids-charantine, alpha-spinasterol, beta cytosterol, stimasterol and derivatives D-galateronic acid.
Green fruit-saponins-diosgenin, triterpine momordicosides, E-1,EX,F', F-1,F-2, G,H,I,J,K,L Fruit pericarpium caratinoids abg caratine derivatives lutein, lycopene, zeaxantine, zeinoxantine.

Amino acids found in seeds-alinine, arginine,asparagines, aspartic acid, glutamic acid, glycine, histadine, leucine, leusine, lysine, ornatine, sterine, tyrosine, vicine, a and b momorcrines, momordine, zeatine and zeatine rhibosides, momordicosides A,B,C,D,E.

The immature cerasee fruit supplies vitamin C and provide some vitamin A, phosphorus, and iron.

Cerasee shows hypoglycemic activity thought to be based on its structural similarity to insulin and stimulation of pancreatic secretion of insulin. Decrease of serum glucose levels has been observed in animal studies and a few human studies. Also, antiviral and antineoplastic activities have been demonstrated in in-vitro studies.

In the Caribbean, cerasee is used as a blood cleanser; bush bath for beautiful skin; and for healing ailments of diabetes, cancer and some infectious diseases. It is also used for all types of stomach complaints including griping or pain in the stomach, amoebas and intestinal parasites and as a laxative. Research confirms these benefits by documenting the anti-bacterial and anti-parasitic properties within cerasee.

In the Caribbean both the fruits and the leaves are used, but this use seems to have evolved differently across the region. For example in Jamaica the leaves find wide acceptance as a tea and the fruit is not eaten, while in Guyana and Trinidad the fruit is used as a side dish or with meats but the leaves are not generally used.

Plate 3.1. Commercial cerasee tea bags sold in Jamaica

Research also shows that the fruit has great potential in treating the AIDS virus. According to Dr Sylvia Mitchell of the University of the West Indies, the cerasee fruit or bitter melon *"is a powerful weapon against the human immunodeficiency virus (HIV) as it contains a series of proteins, dubbed the momorcharins, which have anti-HIV activity. Research has shown that momorcharin can block both the infection of cells by HIV and inhibit HIV replication. A juice extract of cerasee, taken over time is being tested as part of the integrative treatment."*

As previously mentioned, cerasee was always used traditionally as a remedy for diabetes. However, it was later thought that it only masks the true sugar content in the blood, thus giving, false readings of lower blood sugar levels. There is also a traditional belief that cerasee tea (leaves) should be drunk for no more than 9 days in a row.

In another light, numerous studies are showing that the juice of the cerasee fruit has clinically demonstrated blood sugar lowering properties. Charantin, the active ingredient in the fruit is said to be more powerful than the drug tolbutamide, which is sometimes used in the treatment of diabetes to lower the blood sugar levels. However, if one is taking medication for diabetes the juice from the fruit should only drunk under the supervision of a medical doctor. It may potentiate the effectiveness of the drug.

Research done at the University of the West Indies also indicates the potential of cerasee fruit in the fight against cancer; especially leukaemia. Regular use shows increased haemoglobin content for leukemic patients. Some of the other benefits of taking cerasee and its fruit, bitter melon include the curing of colds, fever, sores, menstrual disorder; cerasee also cures "bad blood," gripe and stomach ache.

3.5 Agronomy of cerasee

3.5.1 Varieties

The fruit is normally called bitter melon and comes in a variety of shapes and sizes. The China phenotype is 20 – 30 cm long, oblong with bluntly tapering ends and pale green in colour, with a gently undulating, warty surface. The bitter melon more typical of India has a narrower shape with pointed ends, and a surface covered with jagged, triangular "teeth" and ridges. It is green to white in colour. Between these two extremes are a number of intermediate forms. Some bear miniature fruit of only 6 – 10 cm in length, which may be served individually as stuffed vegetables. These miniature fruit are popular in India and elsewhere in Southeast Asia. The size of leaves also changes in relation to species. The chemical properties, however, remain the same throughout this species. The small fruit variety naturally found all over Jamaica was used in this study.

Plate 3.2. Two contrasting varieties of cerasee one with small fruit and the other with large fruit

3.5.2 Land preparation

Cerasee will grow on a wide range of soil types as is seen by its wide distribution. It however grows best in a friable soil that retains adequate moisture. On light soils, land preparation will only necessitate weed control and the digging of plant holes as the soil will already be friable. If the area selected for cerasee cultivation is on a clay soil it should be ploughed to a depth of at least 30 cm about 1 - 3 months before planting, and allowed to weather properly. After harrowing, the area can be formed into ridges to quickly remove excess water from the plants.

As cerasee is a climbing vine it must be provided with some structure on which it can climb. In the studies at the Mona DTC a trellis was constructed of wooden fence post and 16 guage wire. It is recommended that 2.4 m posts planted a depth of 0.6 m and spaced 2 m apart along the row be used. The wires are then spaced roughly 0.2 m apart in a square grid.

Plate 3.3. Young cerasee vines growing on trellises at Mona DTC

3.5.3 In field planting

Seedlings are transplanted into the field at a spacing of 1 m x 0.3 m. The 1 m inter-row spacing is recommended to allow for the erection of the trellis and allow adequate room for harvesting the leaves. Cerasee can also be planted by seed directly into the soil in field. This will however require planting during the rainy period or ensuring that the soil is kept moist through irrigation. In the plots transplanting from the nursery was used to ensure that seed germination problems were reduced or eliminated in the establishment process.

3.5.4 Growth habit

Cerasse is a vine which has a main stem and several laterals, which themselves have laterals. Figure 3.1 shows the growth parameter measurements for cerasse. Measurements began 9 weeks after transplanting (WAT) and at that time the vine structure was simple in terms of main stem and laterals. Measurements were therefore recorded of heights (main stem lengths) and perpendicular widths (lateral lengths). By 18 WAT, the vine structure had become more complex and it was only possible to do an estimate of percentage trellis cover as a measure of increasing vine growth (Figure 3.2). Cerasse growth parameters also include information on flowering and fruiting. As already mentioned the plants achieved maximum flowering very soon after establishment, and this was followed by fruiting which has been very prolific throughout the life cycle of the plants.

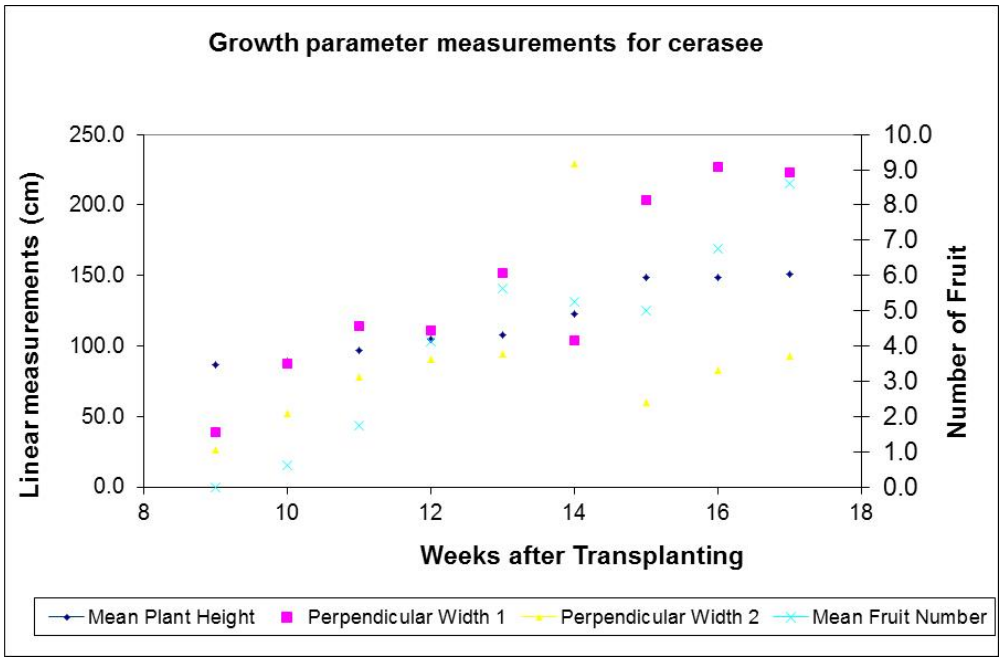

Figure 3.1 Initial growth parameter measurements taken for cerasee

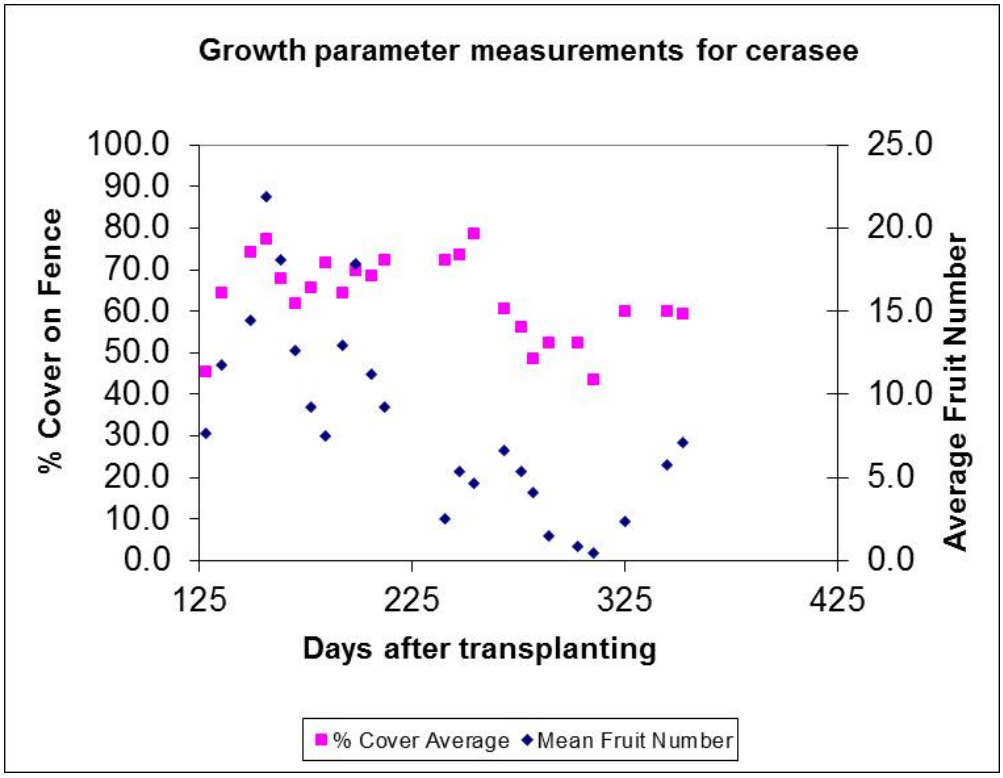

Figure 3.2. Secondary growth parameter measurements taken for cerasee

3.5.5 Cultural practices

Weed control

Cerasee is a climbing vine which grows on a trellis and so does not cover the inter row space. It therefore requires continuous weed control. There are no post-emergence weed control chemicals recommended for cerasee so manual weeding will be necessary to manage the spread of weeds within the plots. When weeding the plots, care must be taken to ensure that the soft stems of the vine which are close to the ground are not accidently cut as this will kill the entire vine.

It was also noticed that clean weeding the plots results in dropped seeds which germinate and produce new vines being removed. This means that this annual vine when it senesces will have to be replanted. It is recommended that some of the drop seed plants be allowed to grow to ensure there is always material growing on the trellis ready to be harvested. It is thought that this is the way the cerasee vine propagates itself in nature.

Plate 3.4. Cerasee vines on trellis with weed free inter rows

Plate 3.5. Trellis with a mixture of old and new vines

Nutrient management

There is no record of synthetic fertilizer use in cerasee production in the region. Fertilizing with synthetic nitrogen is however likely to enhance growth and leaf yield. In the plot at Mona cow manure at the rate of 0.5 kg into each planting hole (15,000 kg/ha) was applied.

Irrigation

In the absence of adequate rainfall, plants will need to be irrigated on a regular basis to ensure adequate growth and development. The use of drip irrigation is recommended as it is acquiring general acceptance in the Caribbean, it regulates the amount of water which is dispensed to each plant root and it uses a small amount of water compared to other irrigation methods.

Pest and disease management

The vines and fruits are affected by a number of biological predators. A scale insect (*Saissetia coffeae*) feeds on the vines, sucking sap from the stem and reducing the quality of the herb for harvest.

Southern Green Stink Bug (*Nezara viridula*) transmits pathogens to fruits growing on the vines. These pathogens spread easily and create a nesting ground for the juvenile stink bugs after infecting the fruit.

Citron bugs (*Leptoglosus gonagra*) feed on the fruits causing fruit drop. To effectively manage these pests organically, Safer Insectide® can be used as prescribed at rate of 18.75 ml/L. An alternative is to use neem oil which can be produced in a crude fashion using the following steps:

Plate 3.6. Scale insect (*Saissetia coffeae*)

Plate 3.7. Southern Green Stink Bug (*Nezara viridula*)

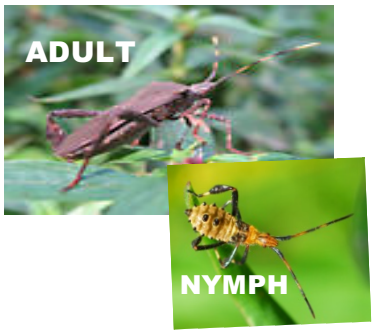

Plate 3.8. Citron bugs (*Leptoglosus gonagra*)

- Cut young branches of the neem tree with green foliage.

- Set the cuttings to solar dry for 24 hours (or longer if desired).
- Fill a large container with water and place the dried neem branches in the water to soak.
- When the mixture begins to form bubbles on the surface, the neem oil has been extracted. There is also a pungent smell which develops when the extraction process is complete. It may take up to 48 hours to reach this stage.
- Filter and strain the mixture so that only the liquid is used in spraying mechanism. Spray treatment is to be done weekly until infestation is under control.

With severe infestations, the vines should be pruned to remove the infected areas and prevent the spread of these pests.

3.6 Harvesting

Maximum yields can be achieved at harvest by allowing the trellis surface area to reach approximately 80% plant coverage; this can be achieved within 4 months after transplanting. When plucking the vines from the trellis care must be taken to avoid cutting the thick main-stem. The leaves and stem areas are the portions to be harvested, so areas with fruit and flowers should be omitted/separated especially if the fruits are old and decaying on the vine. Harvesting is best done by hand, as the entangled vines are challenging to be removed by other means. Fresh weight yield was calculated to be 4000 kg/ha on trellises 1.8 m above ground.

Plate 3.9 Manual harvesting of cerasee vines

3.7 Postharvest handling

Harvested stems and leaves must be washed thoroughly with 5% bleach solution to remove any residue of soil or other contaminants coming from the field. Excess water is allowed to drain away from the stems and leaves which are then placed either in paper bags or on trays lined with mesh netting for drying.

With large amounts of cerasee, drying may best be done by trays lined with mesh netting to prevent any loss of crumbling leaves once dried to brittle crispness. It is ideal to cut the vines into short 15 cm strips, however due to the re-tangling that will occur when put to dry, cutting into smaller strips

may be omitted. The cerasee should be spread so that there is a thickness of about 5 cm, and turned daily to prevent mould build up. After 7 days of solar drying, a mean water loss of 70% by weight is expected. Dried weight yields were calculated to be 1500 kg/ha from the corresponding fresh weight mentioned previously.

Plate 3.10. Cerasee harvest being processed before drying

Plate 3.11. Cerasee drying in trays and paper bags

4. LEMON GRASS

Family: Poaceae (formerly known as Gramineae)
Botanical name: *Cymbopogon spp.*
Popular names: Lemon grass, fever grass
Part Used: Leaf

4.1 History

The name *Cymbopogon* is derived from the Greek words 'kymbe' (boat) and 'pogon' (beard), referring to the flower spike arrangement (Shah, *et al.*, 2011).

4.2 Origin and geographic distribution

Cymbopogon (lemon grass) is a genus of about 55 species of grasses, (of which the type species is *Cymbopogon citratus*) native to warm temperate and tropical regions of the Old World and Oceania. East Indian lemon grass (*Cymbopogon flexuosus*), is native to Cambodia, India, Sri Lanka, Burma and Thailand while the West Indian lemon grass (*Cymbopogon citratus*) is assumed to have its origins in Malaysia.

4.3 Botany

This perennial plant, which belongs to the grass family, is at home in tropical climates. It has smooth, bluish-green leaves consisting of a short, closed sheath at the base and a long, open blade which can grow to a length of up to 150 cm and droops gracefully at the tip. The sharp blades grow in clumps up to 120 cm across and when crushed give off a lemon or citric aroma. Each new leaf grows within the sheath of the youngest leaf. This gives rise to a ring of leaves, thickened at the base, the leaves are encased within each other, onion-fashion, and with the oldest leaves on the outside. Lemon grass produces its ear-like inflorescence annually. Its usual means of spreading is by tillers.

4.4 Nutrition content and uses

The main chemical components of lemon grass oil are myrcene, citronellal, geranyl acetate, nerol, geraniol, neral and traces of limonene and citral.

Cymbopogon citratus is often sold in stem form. Its leaves are used to make tea which can relieve stomach and gut problems. It can also act as an antidepressant and as a mood enhancer. While it can be grown in warmer temperate regions it is not hardy to severe frost.

Plate 4.1. Lemon grass tea bags commercially sold in Jamaica

Plate 4.2. Lemon grass based cosmetic items available in Jamaica

In the folk medicine of Brazil lemon grass is believed to have anxiolytic, hypnotic and anticonvulsant properties, but at least one study has found no effect on humans. It has cytoprotective, antioxidant, anti-inflammatory properties. Citronellol is an essential oil constituent from the *Cymbopogon citratus, Cymbopogon winterianus* and *Lippia alba* which are thought to possess antihypertensive properties. Citronellol has been shown to lower blood pressure in rats, by a direct effect on the vascular smooth muscle leading to vasodilation. In a small randomized controlled trial *Cymbopogon citratus* has been used as an inexpensive remedy for the treatment of oral thrush in HIV/AIDS patients.

It contains 65-85% citral and active ingredients like myrcene, an antibacterial and pain reliever, citronella, citronellol and geranilol. Hydro steam distillation, condensation and cooling were used to separate the oil from the water. Hydrosol or Hydrolat, as a by-product of the distillation process, is a pure natural water or plant water essence used for the production of skin care products such as lotions, creams and facial cleansing toner in its pure form. The main products are organic unadulterated lemon grass oil (for industrial users), and "Negros Oil" (mixture of lemon grass oil with virgin coconut oil) used in aromatherapy.

Lemon grass oil has great benefits as a muscle and skin toner, and revitalizes the body and mind, helps with infections and keeps the family pets flea and tick free and smelling nice.

4.5 Agronomy of lemon grass

4.5.1 Varieties

There are two main varieties of the plant, the East Indian lemon grass (*C. flexuosus*) and West Indian lemon grass (*C. citratus*). Both are used for culinary purposes, and the former mainly for oil extraction. The East Indian variety grows tall, reaching heights of 2.4 m and seeds annually; while the West Indian variety grows shorter, 1 m with thicker stems and has not been recorded seeding.

Plate 4.3. East Indian lemon grass

Plate 4.4. West Indian lemon grass

4.5.2 Land preparation

Lemon grasses are suited to most soil types, they have vigorous fibrous root systems which can penetrate deeply into the soil to uptake nutrients and water. This allows the plants to persist in the dry as well as the wet season. Soil pH should be 5.0 – 6.5. In heavy soils, there needs to be proper tillage to ensure the soil is well aerated and loose enough to aid root penetration. On heavy soils, plough and refine the soil to a depth of at least 20 cm and then prepare ridges spaced 1 m apart to ensure movement of water out of the root zone under high rainfall conditions. Plant holes are then dug 15-20 cm in depth on the ridges to facilitate the planting of the lemon grass plantlets. On lighter soils it may not be necessary to plough and ridge the soil and land preparation may be just clearing the land and digging the plant holes.

4.5.3 In field planting

Lemon grass should be planted to coincide with the rainy seasons if irrigation is not available. Rooted plantlets are planted into the prepared plant holes at a spacing of 1 m x 1 m. They are planted 10-15 cm deep. Plantlets with long leaves can lose much water through transpiration when the weather is hot and dry. Under these conditions it is advisable to prune leaves to decrease the moisture loss. Under ideal conditions plants will establish themselves and begin growing within 2 weeks of transplanting into the field.

Plate 4.5. Transplanting lemon grass plantlets in the field

4.5.4 Growth habit

Initially after transplanting, lemon grass goes through a process of rapid tillering so that the perpendicular width increases faster than the height. After reaching a mean perpendicular width of approximately 150 cm, plant heights then began to increase at a faster rate. Figure 4.1 shows the growth parameter measurements for lemon grass. When measurements began 15 weeks after transplanting (WAT), perpendicular widths had already reached a plateau and mean height had reached about 80 cm. Plant heights steadily increased, initially at about 8 cm per week but after about 22 WAP this slowed to less than 2 cm per week. At this stage the crop is ready for harvesting. This cycle is repeated after harvest and with irrigation plants can be harvested every 3-4 months.

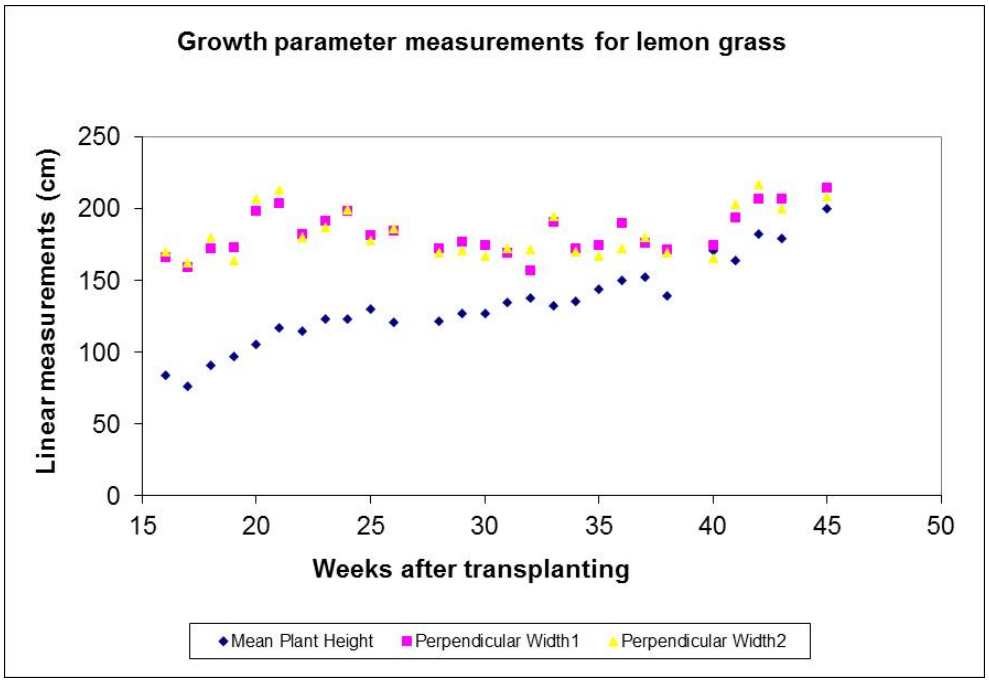

Figure 4.1. Growth parameter measurements taken for lemon grass

4.5.5 Cultural Practices

Weed control

Lemon grass is a very aggressive plant and will quickly tiller and spread its leaves so as to exclude light falling on the inter row. In about 12 weeks after transplanting, the plant canopy will prevent significant weed growth and ultimately exclude weeds. If growth is slow, manual weeding will be necessary to manage the spread of weeds within the plots in the early period after transplanting.

Nutrient management

There is no record of synthetic fertilizer use in lemongrass production in the region. Fertilizing with synthetic nitrogen is however likely to enhance growth and leaf yield. In the plots at Mona and Sam Motta vermiculture at the rate of 0.5 kg into each planting hole (5,000 kg/ha) was applied.

Irrigation

In the absence of adequate rainfall, irrigation on a regular basis will maintain high soil moisture levels and ensure that there is optimum growth and development of leaves. The use of drip irrigation is recommended as it is acquiring general acceptance in the Caribbean, it regulates the amount of water which is dispensed to each plant root and it uses a small amount of water compared to other irrigation methods.

Pest and disease management

The main pest found on Lemon grass was a scale insect (*Pseudaulacaspis cockerelli*) which feeds on the leaves, sucking sap, discolouring the leaf blades and reducing the quality of the product at harvest.

This pest is effectively managed by spraying the leaves with Safer Insectide® or Orchard Oil® at the rate of 18.75 ml/L. Crude Neem oil produced on farm can also be used (see pages 26-27).
If the infestation is severe, the affected leaves should be pruned to stimulate re-growth and prevent the further spread of the pest. It also improves the quality of the final harvest.

Plate 4.6. Scale insect (*Pseudaulacaspis cockerelli*)

4.6 Harvesting

Lemon grass should be allowed to develop for 6 months after transplanting before being harvested for the first time. Lemon grass can then be harvested at intervals, 3 - 4 times a year, with care not to cut it too low. At least 10 cm of stump should be left for regrowth. When clumps become too large, the upper portion of the leaves can be reaped and then the clumps subdivided and planted back in a nursery. Some shade should be placed over these subdivided plants to allow for root regeneration. The leaf blade is the targeted harvest area, avoiding the thick stem sheath (due to its higher moisture content).

Apparatus required for harvesting includes rope and a blade (machete, saw, sickle etc). Using the rope to wrap around the outer layer of lemon grass, constrict it to bunch all the leaf stalks together. Once bounded, the blade is used to cut through the base of the bunch at a height of about 10 – 15 cm from ground level. From calculations, the fresh weight of leaves is expected to be 9,800 kg/ha.

Plate 4.7. Harvesting lemon grass plots

Plate 4.8. Lemon grass stools after harvest

4.7 Postharvest handling

Harvested leaves must be washed thoroughly with 5% bleach solution to remove any residue of soil or other contaminants coming from the field. Excess water is allowed to drain away from the leaves which are then ready for drying.

After cutting through the bunch, cut each leaf blade into 10 cm strips. Whilst cutting the strips maintain quality control by removing unwanted matter (dried leaves, leaf sheath, diseased areas, foreign matter etc.) from the bulk of material. These strips can be solar dried in either large paper bags or on perforated trays using 0.25 kg of leaves per container. Leaves should be turned on a regular basis (twice daily at least) to ensure even drying occurs throughout the container. Under these conditions a mean water loss of 70% and 63% were seen in 7 days using the trays and the paper bags respectively.

An alternative to cutting the strips while the leaves are green is to keep them as full length blades and bind them in the middle, to prevent leaves from slipping out, and also by the base for suspension using polyvinyl rope. These bundles can be suspended by the polyvinyl rope in a solar drying facility and left to air dry. A mean water loss of 73% was recorded after 7 days of drying

by hanging. This method maximizes the volume to area ratio, allowing for more to be dried in a small space. If the leaf bundles are hung, there will be no need to have them turned occasionally as there should be enough air circulation for even drying.

From calculations, the dried weight of leaves is expected to be 2,060 kg/ha.

5. PEPPERMINT

Family: Lamiaceae (Labiatae)
Botanical name: *Satureja viminea*
Popular names: Peppermint, Jamaica peppermint
Part Used: Leaf

5.1 History

The Jamaica peppermint does not belong to the mint (M*entha sp*) family but to the savoury (*Satureja sp*) family. The Latin genus name, *Satureja*, is derived from the Arabic *za'atar* or *sa'tar.* Savoury is said to be one of the oldest flavoring herbs. It has also long held a reputation as a medicinal. The Romans valued savoury highly and used its hot peppery flavour before eastern spices were widely known. They are also credited with having spread it throughout Northern Europe. The ancient Roman poet Virgil recommended planting savoury near beehives, as bees are extremely attracted to savoury blossoms. The Roman writer Pliny the Elder (77 A.D.) reported savoury's frequent use as a meat and sauce seasoning.

5.2 Origin and geographic distribution

There are 30 species in the *Satureja* genus, but only two are at all well-known, summer savoury *(Satureja hortensis),* a shrubby annual; and winter savory *(Satureja montana),* a hardy perennial shrublet. Summer and winter savory are native to the Mediterranean region (France, Spain, Italy, and the Balkans); the Ukraine; Turkey, Lebanon, and Israel. Both summer and winter savoury were among the herbs brought to North America by European settlers; they are listed as such by John Josselyn in his *New England's Rarities Discovered* (1672).

Jamaican mint bush or *Satureja viminea* became naturalized in the West Indies, where it is locally known as "peppermint", although it does not belong to the mint (*Mentha sp*) family and is more closely related to thyme (*Thymus sp*) and rosemary (*Rosmarinus officinalis*). Peppermint also goes by the names: savoury, serpentine savoury, Kama Sutra mint and Costa Rican mint. The aromatic nature of the plant is so similar to mint that it is also traditionally used as a culinary and medicinal herb.

5.3 Botany

Satureja species may be annual or perennial. They are low-growing herbs and sub-shrubs, reaching heights of 15 – 50 cm. The leaves are 1 - 3 cm long, with flowers forming in whorls on the stem, white to pale pink-violet.

Satureja viminea is a large shrub or small tree with glossy, lime green, 0.5 - 2.5 cm long oval leaves. The plant has a woody stem and upright growth, though it keeps a bushy shape. It can be trained into a small tree which reaches 1- 1.3 m in height. The leaf veins are etched on the upper surface. It normally has numerous blossoms with a corolla that is white with very faint pinkish tinge, slightly irregular (the lower lobe about twice as large as others).

5.4 Nutrition content and uses

Satureja viminea is nutritious and is considered to have antioxidant, digestive, expectorant, sedative, stomachic and carminative qualities. It is a source of protein, carbohydrate and dietary fiber, which helps lower LDL or bad cholesterol. *Satureja,* or herbs of the savory family, contain the flavonoids vitamin A or beta-carotene, vitamin C and B complex vitamins. They are a source of the minerals, iron, calcium, magnesium, niacin, thiamine, potassium and zinc.

The essential oils of Jamaican peppermint contain pulegone, a type of monoterpene, which produces the herbs minty scent, also found in pennyroyal (*Mentha pulegium*). Pulegone has traditionally been used to repel mice and insects, suggesting that it is mildly toxic, although research has revealed that heating plant leaves that contain the substance helps neutralize any harmful effects.

Essential volatile oils from plants in the Satureja genus, such as winter savory and Jamaican peppermint, contain a number of important compounds such as carvacrol, thymol and p-cymene. Both thymol and carvacrol have antiseptic, antifungal properties and are produced and used in the food industry as preservatives or food additives. Moreover, researchers in the pharmaceutical industry have discovered that compounds in the herbs have anti-inflammatory activities, comparable to morphine, and can be used to develop anti-inflammatory, analgesic drugs.

In the Caribbean, particularly in Trinidad and Jamaica, Jamaican peppermint leaves are ground and used as a spice to season meats. This herb often replaces mint in recipes, including the Jamaican version of the mojito, which is made with dark rum as opposed to white rum used in the traditional Cuban cocktail. Jamaican peppermint leaves are also used to make a refreshing herbal breakfast tea, sometimes combined with ginger and sugar for added flavour. Medicinally, the tea is known as a remedy for colic; it has curative properties and improves digestion.

This may be one of the most important of the medicinal herbs, since it contains Menthol oil, aids in digestion, helps to calm nerves, fights bacteria and helps in the prevention of unwanted microbes that may colonize in the digestive tract. It is commonly used as a mouth wash cavities.

Commercially the plant is used for making the famous Kama Sutra Luxury Mint Tree Bath Gel and Body Wash. This voluptuous cleansing liquid has a dedicated worldwide following of men and women who know bathing's true pleasure potential. The Kama Sutra Mint Tree Bathing Gels are a great way to turn the simple ritual of a bath or shower into a sensual interlude with these indulgent bathing gels. Mint Tree cools and tingles, invigorating the body and lifting the spirit.

Plate 5.1. Commercial tea bags made with Jamaica Peppermint

5.5 Agronomy of peppermint

5.5.1 Varieties

Satureja viminea, the Jamaican peppermint has only one variety.

Plate 5.2. The sole variety of Jamaican peppermint known

5.5.2 Land preparation

Jamaican peppermint is suited to a light free-draining soil conditions such as sands and loams. These loose, friable soils allow the strong tap root system of the plant to penetrate deeply into the soil to uptake nutrients and water. Heavier soils will require proper soil tillage to ensure the soil is well aerated and loose enough to aid root penetration. Soil pH should be 5.0 – 6.5. On heavy soils, the soil should be ploughed and refined to a depth of at least 20 cm and then ridged at a spacing of 1 m apart to ensure movement of water out of the root zone under high rainfall conditions. Plant holes are then dug 15 - 20 cm in depth on the ridges to facilitate the planting of the peppermint plantlets. On lighter soils it may not be necessary to plough the soil but ridges should be made with a hoe or other small implement, as the peppermint plant cannot endure any waterlogging.

Plate 5.3. Young peppermint plants growing without tillage at the Sam Motta DTC

5.5.3 In field planting

Jamaican peppermint should be planted to coincide with the rainy seasons if irrigation is not available. Rooted plantlets are planted 10 - 15 cm deep into the prepared plant holes at a spacing of 1 m x 1 m. Under ideal conditions plants will establish themselves and begin to produce new stems and leaves within 2 weeks of transplanting into the field.

Plate 5.4. Peppermint seedlings recently transplanted

Plate 5.5. Early growth of peppermint plant

5.5.4 Growth habit

Peppermint plants are shrubs, and compared to blackmint is a relatively slow grower. Figure 5.1 shows the growth parameter measurements for peppermint. When measurement of growth began 10 weeks after transplanting (WAT), mean plant heights were approximately 40 cm and by 20 WAT mean heights had only progressed to 55 cm, approximately 1.5 cm per week. After 20 WAT the plants had serious infestations of scale insects which were controlled by pruning. The decrease in mean plant height recorded is as a result of the pruning from about 23 WAT to 30 WAT. With heavy rains there was a marked decrease in the level of scale insect infestations. The heavy downpours seem to wash away the insects from the surface of the plants. The mean plant heights also steadily increased from 30 WAT.

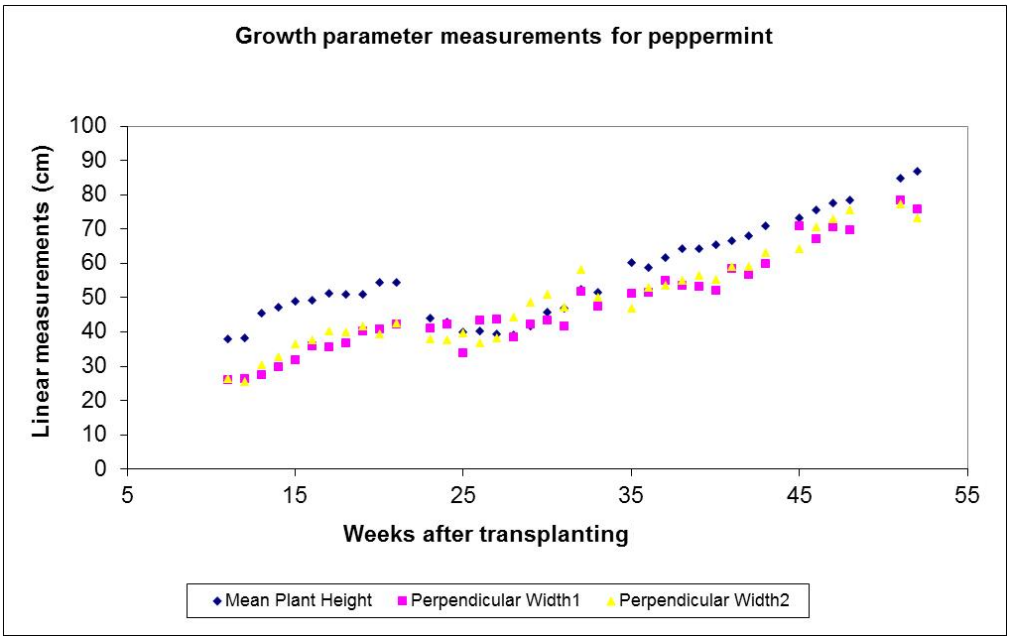

Figure 5.1. Growth parameter measurements taken for peppermint

5.5.5 Cultural practices

Weed control

The peppermint plant grows rapidly under ideal conditions but does not spread over the inter-row space enough to exclude weeds. Manual weeding is therefore necessary to manage the spread of weeds within the plots. Weeding along the walkway and around the plots is also an important sanitary method and can help to prevent the spread of weeds into the plot and also reduce pest incidence. The use of grass mulch to suppress weeds and conserve soil moisture was tried at Sam Motto DTC with beneficial results. During the dry season there is likely to be more weeding infestation as the plants will reduce their rate of growth.

Plate 5.6. Peppermint plants with high weed infestation at the Mona DTC

Plate 5.7. Mulching of Peppermint plants at for weed control and moisture conservation at Sam Motta DTC

Nutrient management

There is no record of synthetic fertilizer use in peppermint production in the region. Fertilizing with synthetic nitrogen is however likely to enhance growth and leaf yield. In the plots at Mona and Sam Motta organic manure at the rate of 0.5 kg into each planting hole (5,000 kg/ha) was introduced. In both Mona and Sam Motta DTCs vermi-compost made from goat dung was used.

Irrigation

In the absence of adequate rainfall, plants will need to be irrigated on a regular basis to ensure adequate growth and development. The use of drip irrigation is recommended as it is acquiring general acceptance in the Caribbean, it regulates the amount of water which is dispensed to each plant root and it uses a small amount of water compared to other irrigation methods. Mulching can also be practice to conserve soil moisture

Pest and disease management

The peppermint plant is affected by the Nettle Ensign Scale (*Orthezia urticae*) which feeds on the stems, sucking sap and reducing the quality of the leaves at harvest. With severe infestations, sooty mold may develop on the stem due to the honeydew being deposited by the scale.

To effectively manage these pests organically, Safer Insectide® can be used as prescribed at rate of 18.75 ml/L.

An alternative is to use neem extract which can be produced in a crude fashion (see pages 26-27)

Plate 5.8 Nettle Ensign Scale (*urticae*)

5.6 Harvesting

Jamaican peppermint has potency in the leaves of the shrub, and in order to reap these benefits, the plant will need time to develop sufficiently for its first harvest. After being hardened and transplanted to the field, the plant must be allowed to grow for about 6 months before the first

harvest. With good management and tending of the plot, harvesting may be carried out every 3-4 months thereafter.

The area of interest for harvesting are the young leaves which are on the green stem areas of the plant which have not yet matured to a dark green foliage on woody stems. Preference is given to the green stems which are about the size of match sticks and leaves that are light green in hue; however older leaves and thicker stems may be harvested to relieve the plant of the foliage it has borne.

The tools needed for harvesting are sharp secateurs and large portable containers (bags, boxes etc). The harvesting technique is to select the stems as described and clip them immediately above a node to permit re-growth from these green zones. The older stems which may have become hardened at the lower branches may be clipped directly from the main stem if there are no emerging stem shoots on that branch. Caution must be applied when harvesting; if the plant is cut back too much leaving only woody stems and no green areas with nodes the plant may become stunted and severely limit productivity or worst it may die back. Once clipped, the peppermint cuttings can be placed into a large container for ease of transport out of the field From calculations, the fresh weight of clipped leaf and stem is expected to be 1,000kg/ha.

5.7 Postharvest handling

Harvested stems and leaves must be washed thoroughly with 5% bleach solution to remove any residue of soil or other contaminants coming from the field. Excess water is allowed to drain away from the stems and leaves which are then placed in paper bags for drying.

The Jamaican peppermint has a very frail petiole when dried, so it is best to solar dry the cuttings in a container such as a large paper bag to prevent scattering of leaves during the drying process. The cuttings should be set at about 0.25 kg per paper bag and spread evenly around the sides of the bag to prevent mould build up. Cuttings should be turned daily as well to allow even drying, ensuring that mould is not developing and observing the defoliation as the cuttings dry. Solar drying is expected to be completed within 7 days with mean percentage water loss of about 75% by weight. To further sort the dried product, the dried leaves must be separated from the dried stems by clasping the stems and either pressing/wringing them together or rubbing them over a container to capture the leaves which did not separate from the stem during the drying process. From calculations, the dried weight of leaves only is expected to be 160kg/ha.

6. SORREL

Family: Malvaceae
Botanical name: *Hibiscus sabdariffa*
Popular names: Roselle, sorrel, red sorrel, Jamaica sorrel
Part Used: Leaf,

6.1 History

The roselle (*Hibiscus sabdariffa*) is a species of hibiscus native to the Old World tropics and there are two main types. The more important economically is *H. sabdariffa* var. *altissima* Wester, an erect, sparsely-branched annual which grows up to 4.8 m high, and is cultivated for its jute-like fibre in India, the East Indies, Nigeria and to some extent in tropical America.

The other distinct type of roselle, *H. sabdariffa* var. *sabdariffa,* embraces shorter, bushy forms which have been described as races: *bhagalpuriensi, intermedius, albus,* and *ruber,* all breeding true from seed. The first has green, red-streaked, inedible calyces; the second and third have yellow-green edible calyces and also yield fibre. In this manual, the race *ruber* and its named cultivars with edible calyces will be the main focus.

6.2 Origin and geographic distribution

Sorrel is native from India to Malaysia, where it is commonly cultivated, and must have been carried at an early date to Africa. Seeds are said to have been brought to the New World by African slaves. It has been widely distributed in the Tropics and Subtropics of both hemispheres, and in many areas of the West Indies and Central America has become naturalized. Roselle was grown in Brazil in the 17th century and in Jamaica in 1707. The plant was cultivated for food use in Guatemala before 1840. J.N. Rose, in 1899, saw large baskets of dried calyces in the markets of Guadalajara, Mexico.

6.3 Botany

*H. sabdariffa v*ar. *sabdariffa* race *ruber* is an annual, erect, bushy, herbaceous sub-shrub up to 2.4 m tall, with smooth or nearly smooth, cylindrical, typically red stems. The leaves are alternate, 7.5 - 12.5 cm long, green with reddish veins and long or short petioles. Leaves of young seedlings and upper leaves of older plants are simple; lower leaves are deeply three to five to seven lobed; the margins are toothed. Flowers, borne singly in the leaf axils, are up to 12 cm wide, yellow or buff with a rose or maroon eye, and turn pink as they wither at the end of the day. At this time, the typically red calyx, consisting of five large sepals with a collar (epicalyx) of 8 - 12 slim, pointed bracts (or bracteoles) around the base, begins to enlarge, becoming fleshy, crisp but juicy, 3 - 6 cm long and fully encloses the velvety capsule, 1 - 2 cm long, which is green when immature, five-valved, with each valve containing three to four kidney-shaped, light-brown seeds, 3 - 5 mm long and minutely downy. The capsule turns brown and splits open when mature and dry. The calyx, stems and leaves are acid and closely resemble the cranberry *(Vaccinium spp.)* in flavour.

6.4 Nutrition content and uses

The plants are rich in anthocyanins, as well as protocatechuic acid. The dried calyces contain the flavonoids gossypetin, hibiscetine and sabdaretine. The major pigment, formerly reported as hibiscin, has been identified as daphniphylline. Small amounts of myrtillin (delphinidin 3-

monoglucoside), chrysanthenin (cyanidin 3-monoglucoside), and delphinidin are also present. Roselle seeds are a good source of lipid-soluble antioxidants, particularly gamma-tocopherol.

The whole plant can be used as food, inclusive of the leaves, flowers and fruit. Traditionally the fruit is primarily used to make seasonal beverages, chutney, and jams. Sorrel is currently being promoted as a substance with anti-cancer, diuretic, cardiovascular and antihypertensive properties. Its host of vitamins, minerals and antioxidants helps to make sorrel a powerful nutraceutical.

In the Caribbean and Central America sorrel drink is made from sepals of the roselle. In Mexico, 'agua de Flor de Jamaica' (water flavored with roselle) frequently called "agua de Jamaica" is most often homemade. Also, since many untrained consumers mistake the calyces of the plant to be dried flowers, it is widely, but erroneously, believed that the drink is made from the flowers of the non-existent "Jamaica plant". The sorrel drink is one of several inexpensive beverages (aguas frescas) commonly consumed in Mexico and Central America, and they are typically made from fresh fruits, juices or extracts.

In the Caribbean it is prepared by boiling dried sepals and calyces of the sorrel plant in water for 8 - 10 minutes (or until the water turns red), then adding sugar. It is often served chilled. In Jamaica additional flavour is provided by brewing the drink with ginger and adding rum. It is a popular drink of the country especially during the Christmas season. It is also very popular in Trinidad and Tobago and Guyana but cinnamon and cloves are preferred to ginger. The Carib Brewery Trinidad Limited, a Trinidad and Tobago brewery, produces a Shandy Sorrel in which the sorrel drink is combined with beer.

Plate 6.1. Commercial tea bags made from dry sorrel calyx

Plate 6.2. Sorrel drink a very popular beverage in the Caribbean

6.5 Agronomy of sorrel

6.5.1 Varieties

There are three edible varieties of sorrel in Jamaica. These are the traditional red sorrel (Rico), early bearing red sorrel (Victor) and white sorrel (Archer). The traditional red sorrel only bears in the first and last quarters of the year; the early bearing red sorrel can bear all year round, independent of season while the white sorrel bears fruit with no red pigment (white fruits).

Plate 6.3. Three varieties (l-r) traditional red sorrel (Rico), early bearing red sorrel (Victor) and white sorrel (Archer)

6.5.2 Land preparation

Sorrel prefers a light free-draining soil but can grow on all soils. It has a strong tap root system which penetrates deeply into the soil to uptake nutrients and water. Heavier soils will require proper soil tillage to ensure the soil is well aerated and loose enough to aid root penetration. Soil pH should be 4.5 – 7.0. On heavy soils, plough and refine the soil to a depth of at least 20 cm and then prepare ridges spaced 1m apart to ensure movement of water out of the root zone under high rainfall conditions. If seedlings are being used, plant holes are then dug 15 - 20 cm in depth on the ridges to facilitate the transplanting of the seedlings. On lighter soils it may not be necessary to plough the soil but ridges should be made as any waterlogging can be detriment to the sorrel plants.

6.5.3 In field planting

Seedlings may be raised in the nursery and transplanted when 7.5 - 10 cm high. However, any damage to the roots during transplanting can increase the susceptibility of the seedlings to any soil borne diseases. Seeds are usually set directly in the field, at four to six per hole and with holes spaced 1 m x 1.5 m. When two or three leaves have developed, the seedlings are thinned out by 50%.

Sorrel is a short day plant and photoperiodic, the ideal planting time in the Caribbean is mid-May. The plants will then have enough time for adequate vegetative growth before flower initiation in September and October. The calyces will develop and be ready to harvest in November and December. The early bearing red sorrel is able to be planted all year round and bear fruit within 3 - 4 months; however the best yields occur when planted in the regular season of the last two quarters of the year when day length is shortening.

Plate 6.4. Early bearing red sorrel which flowers soon after planting

6.5.4 Growth habit

Sorrel is a shrub, but as an annual grows much faster than peppermint. Figure 6.1 shows the growth parameter measurements for sorrel. Measurement began 7 weeks after planting (WAT) and plant mean heights increased steadily for the next 7 weeks at about 10 cm per week. After that time, and with the advent of rain and wetter soil conditions, the plants began to dieback. This dieback is thought to be as a result of *Sclerotia spp* a soil borne disease. The dieback is reflected in the decrease in mean plant height of sorrel recorded from 19 WAT.

Sorrel achieves 50% flowering within 7 weeks after planting, with sufficient fruiting and readiness around 15 - 20 weeks after planting. Early pruning will increase branching and development of more flowering shoots. Harvesting causes latent buds to develop and extends the flowering life of the plant to late February. When the fruit is not gathered but left to mature, the plants will die by January after the harvesting is completed.

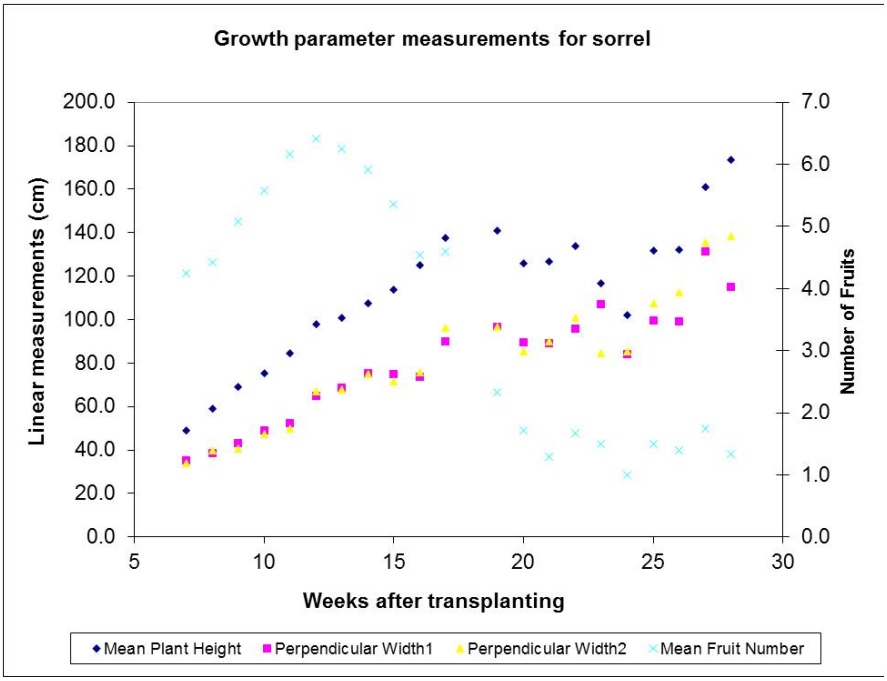

Figure 6.1. Growth parameter measurements taken for sorrel

6.5 Cultural practices

Weed control

Weed control is necessary early in the life of the crop, but after the plants reach 45 - 60 cm in height, weeds will be shaded out. Manual weeding is therefore necessary to manage the spread of weeds within the plots during the 4 - 8 weeks after planting. The use of grass mulch to suppress weeds and conserve soil moisture under dry conditions can be beneficial.

Nutrient management

Morton and Dowling (1987) report that commercial fertilizer of the formula 4-6-7 NPK has given satisfactory yields. But it is also stated that an excess of nitrogen encourages vegetative growth and reduces fruit production. In the plots at Mona vermi-culture made from goat manure at the rate of 0.5 kg (3,330 kg/ha) was introduced into each planting hole.

Irrigation

In the absence of adequate rainfall, plants will need to be irrigated on a regular basis to ensure adequate growth and development. The use of drip irrigation is recommended as it is acquiring general acceptance in the Caribbean, it regulates the amount of water which is dispensed to each plant root and it uses a small amount of water compared to other irrigation methods. Mulching can also be practice to conserve soil moisture.

Pest and disease management

Sorrel's major enemy is the root-knot nematode, *Heterodera rudicicola.* Mealybugs may also be very troublesome. The "white" roselle has been found heavily infested with the cocoa beetle, *Steirastoma breve* in Trinidad, with a lighter infestation of the red roselle in an intermixed planting.

Occasional minor pests are scales, *Coccus hesperidum* and *Hemichionaspis aspidistrae,* on stems and branches; yellow aphid, *Aphis gossypii,* on leaves and flower buds; and the cotton stainer, *Dysdercus suturellus,* on ripening calyces.

A soil disease thought to be caused as a result of *Sclerotia spp.* can arrest plant growth at any stage of development resulting in defoliation (leaf loss) and ultimately die back. The disease is prevalent in both wet and dry conditions; however the severity is greater in wet conditions.

Plate 6.5. Young sorrel plants in the field showing and area of dieback (l) and a close up a more mature planting showing signs of dieback (r)

One means of addressing this challenge is to prevent waterlogging of the soil by not over watering and planting seeds atop of mounds. If the soil disease persists, solarization using a plastic tarp to cover the land area is recommended before planting, using the following guidelines:

Solarization Process

- Till the soil to depth of 30 - 40 cm.
- Wet the soil to depth of 50 - 60 cm.
- Rolling the soil to a smooth surface prior to spreading the plastic mulch is advisable; this prevents damage to the tarp from an unlevelled surface.
- Thinner plastics are best at reducing reflection of light rays while allowing the rays to penetrate into the soil and heat the covered area.
- Leave the plastic mulch in place for 4 – 6 weeks.
- Solarization is best done in the months of May – September (continuous hot periods; best months vary depending on geographic location).
- The best types of tarp material to use in the mulching are either
    - Polyethylene tarp
    - Polyvinyl chloride tarp.
- Material should have thickness in the range of 0.5 – 4 mm.
- Bury the edges of the tarp 12 – 16 cm in the soil leaving areas accessible to set a hose under the tarp occasionally in order to maintain moisture within soil (do not allow the soil to be completely dry or completely saturated).

6.6 Harvesting

The fruits are harvested when full-grown but still tender and, at this stage, are easily snapped off by hand. They are easier to break off in the morning than at the end of the day. If harvesting is overdue and the stems have toughened, fruits can be harvested from the plant easily by using a pair of secateurs/clippers to cut away the mature fruit from the stems. From the fruit, the outer red calyx is the section of the fruit desired. By de-coring the seed capsule, the fleshy red calyx is obtained. The seed capsules can be emptied of their contents to obtain a stock of seeds which can be used for another set of sowing. The calculated fresh weight yield of calyces was 1,050kg/ha.

Plate 6.7. De-coring of sorrel with metal pipe to separate seed capsule and calyx

6.7 Postharvest handling

Having de-cored the seed capsule from the calyx; the calyx is better suited to solar drying in a tray. Wash the harvested calyces in a 5% bleach solution and allow to drain, then spread the calyces thinly on a flat aerated tray, to a maximum thickness of 5 cm and turn daily to prevent mould build up and allow for even drying. After a week of solar drying, weight loss due to water loss from the calyces is expected to reach about 80%. From calculations, the dried weight of calyces is expected to be 140kg/ha.

Plate 6.8. Dried calyx of sorrel which were solar dried

7 Drying Storage and Transportation

7.1 Drying

For the herbal species described in this manual the commercial products of interest varied from the young leaves and the stems of blackmint and cerasee, the leaf blades of lemon grass, the leaves of peppermint and the leaves of peppermint and the sepals from sorrel. After harvesting in the

field these products had to be suitably extracted in a sanitary area before the drying process was done.

All the products were dried using a solar dryer specially constructed for the purpose. The solar dryer consisted of a 4.5 m x 9.0 m (15 ft x 30 ft) frame of wood and metal enclosed by a 30% knitted polyethylene mesh sides and covered by a translucent plastic roof. In the dryer, trellising wires were strung up to accommodate herbs to be dried by hanging. Wire rope was used as the trellising wires, running about 2.4 m (8 ft) from ground level with each length being re-enforced every 3 m (10 ft) by a cross-beam. Perforated metal tables were also placed inside to provide facilities for the various drying procedures. The floor was covered by black mulch sheeting to control the growth of weeds and decrease the movement of moisture from the soil.

Plate 7.1. Solar drier used at the Mona DTC

Plate 7.2. Lemon grass being dried by hanging on lines in the solar drier

Using this facility three drying procedures were used

1. Hanging
2. In trays
3. In paper bags.

The hanging method was especially used for lemon grass leaf blades which were bound by polythene chord and suspended from cables running along the top of the solar drying house. The other two methods used lemon grass leaves and the commercial products of all the other crops. Owing to variations in climatic conditions, the temperatures fluctuating in the structure were between 20^{o}C – 50^{o}C. The drying methods were quite effective and within 1 week from harvest many of the products were dried to constant weight and ready for storage.

Plate 7.3. Cerasee drying in trays and paper bags

7.2 Storage and transportation

It is estimated that in the tropics each year between 25 and 40% of stored agricultural products are lost because of inadequate and village-level storage. In the field and during storage the products are threatened by insects, rodents, birds and other pests. Moreover, products may be spoiled by infection from fungi, yeasts or bacteria. In order to minimize the losses during storage it is important to know the optimum environmental conditions for storage of the product, as well as the conditions under which attackers flourish.

Biological activity occurs only when moisture is present. Therefore the moisture content of the product itself, as well as the moisture content of the surrounding air, is important for safe storage. Each product has its own characteristic balance (or equilibrium) between the moisture it contains and the water vapour in the air surrounding it. This equilibrium is known as the moisture content/relative humidity pattern.

The moisture content of a product is expressed as a percentage of the wet weight as follows:

$$\text{Moisture content (\%)} = \frac{\text{Weight of water in the moist product}}{\text{Weight of the moist product}} \times 100$$

The relative humidity is a percentage measurement of the amount of moisture (water vapour) actually in the air as compared to the maximum amount of moisture which the air could hold at that temperature.

In formula, for a certain temperature:

$$\text{Relative humidity (\%)} = \frac{\text{Amount of water vapour present in the air}}{\text{Maximum amount of water vapour that air of that temperature can contain}} \times 100$$

The maximum allowable moisture content for safe storage of a dried product, known as the safe moisture content is taken to be the equilibrium moisture content which corresponds to a relative humidity of 65 -70%. When a product's moisture content is equal to or below the safe moisture content, the danger of attack by bacteria and fungi is negligible.

Warm air can hold more moisture than cold air, therefore, if the amount of moisture in the air is constant and the temperature increases, the relative humidity will decrease. A temperature increase of 1°C results in a decrease of about 4% in the relative humidity of the heated air. There is therefore a very wide variation in the relative humidity of the area between the hottest time of the day and the coldest time of the night even if there is no extract moisture added to the air. The moisture content of dry products will vary with this change in relative humidity, so that dried products at equilibrium with a relative humidity of 65 -70% during the day will actually gain moisture from the air during the night and become moist. This can occur even in sealed containers particularly if there is much air compared to the amount of dried product

Dried herbal products should ideally be stored in sealed air less containers (vacuum packed) to ensure their long maintenance. In the absence of this technology the dried product should be packed tightly into the container to exclude as much air as possible before it is sealed. The use of a zip-loc plastic bag is ideal for small amounts of product, but care must be taken to remove as much air from the bag before closing the zip-loc.

Plate 7.4. Dried peppermint leaves

Plate 7.5. Dried lemongrass blades

The best containers for herbal products are glass or earthen jars with dark colouration as they do not contaminate the herbs over time (as plastics do) and they protect the product from any harmful reactions from light and temperature fluctuations. Under these conditions, storage may last for years without spoilage. It must be noted that herbs retain their oil and flavour if stored whole and crushed just before use.

Fresh herbs have a shorter shelf life and require refrigeration to maintain that state. Lemon grass and sorrel are sold both fresh and dried. Fresh lemon grass is normally tied together and refrigerated but not bagged. Fresh sorrel is however bagged and refrigerated. The plastic bags are however perforated to allow the movement of respiration products out of the bags. The shelf life of fresh products is relatively short compared to properly stored dried products.

Bibliography

Akhila A (ed.). 2010. Essential oil-bearing grasses: the genus *Cymbopogon*. Boca Raton, FL: CRC Press Taylor & Francis Group

Akhila, A. 2010. Chemistry and biogenesis of essential oil from the genus *Cymbopogon*. In: Akhila A (ed.) Essential oil-bearing grasses: the genus *Cymbopogon*. Boca Raton, FL: CRC Press Taylor & Francis Group, pp. 25-106

Ansari M A and Razdan R K. 1995. Relative efficacy of various oils in repelling mosquitoes. Indian J Mal 32:104-111

Bansod S and Rai M. 2008. Antifungal activity of essential oils from indian medicinal plants against human pathogenic *Aspergillus fumigatus* and *A. niger*. World Journal of Medical Sciences 3:81-88

Barnett A. 2011. Adding value to Jamaican herbs and spices: reducing postharvest losses and expanding market opportunities. Jamaica: Scientific Research Council

Basch E, Gabardi S and Ulbricht C. 2003. Bitter melon (Momordica charantia): a review of efficacy and safety. Am J Health Syst Pharm. 60:356-359

BCC Research. 2008. Nutraceuticals: global markets and processing technologies. USA: BCC Research
http://www.bccresearch.com/report/FOD013C.html

Bertea C M and Maffei M E. 2010. The genus *Cymbopogon*: botany, including anatomy, physiology, biochemistry, and molecular biology. In: Akhila A (ed.) Essential oil-bearing grasses: the genus *Cymbopogon*. Boca Raton, FL: CRC Press Taylor & Francis Group, pp. 1-24

Blanco M M, C.A.R.A. Costa, Freire A O, Santo J G Jr. and Costa M. 2009. Neurobehavioral effect of essential oil of *Cymbopogon citratus* in mice. Phytomedicine: International Journal of Phytotherapy and Phytopharmacology 16:265-270

Buckle J. 2003. Clinical Aromatherapy. New York, NY: Churchill Livingstone

CARDI. 2009. Research and development highlights - Jamaica. Mona, Jamaica: Caribbean Agricultural Research and Development Institute

CBI. 2007. The spices and herbs market in the EU, 2007

Devi R C, Sim S M and Ismail R. 2011. Spasmolytic effect of citral and extracts of *Cymbopogon citratus* on isolated rabbit ileum. J. Smooth Muscle Res. 47:143-156

do Vale T G, Furtado E C, Santos J G Jr. and Viana G S B. 2002. Central effects of citral, myrcene and limonene, constituents of essential oil chemotypes from *Lippia alba* (Mill.) N.E. Brown. Phytomedicine: International Journal of Phytotherapy and Phytopharmacology 9:709-714

Erich O A and Beitl R. 1955. Folk Medicine. Chicago: University of Chicago Press

Export Centre and Business Information Point and the Jamaica Exporters Association, 2008. Market Brief on Essential Oils. http://ecbip.com/download_pdf.php?filename=documents/sections/document_Essential_Oils_110809172.pdf

Food and Agriculture Organization. 2007. FAOSTAT data http://faostat.fao.org/default.aspx

Folorunso A E and Oyetunji O A. 2007. Comparative folier epidermal studies in *Cymbopogon citratus* (Stapf.) and *Cymbopogon giganteus* (Hochst.) Chiov. in Nigeria. Not. Bot. Hort. Agrobot. Cluj 35(2):7-14 http://www.notulaebotanicae.ro/index.php/nbha/article/view/198/194

Ganjewala, D. 2008. RAPD Characterization of Three Selected Cultivars OD-19, GRL-1 and Krishna of East Indian Lemongrass (*Cymbopogon flexuosus* Nees ex Steud) Wats. American-Eurasian Journal of Botany 1(2):53-57

German Commission E. [1990]. Lemongrass, Citronella. Monograph. Retrieved on January 10, 2011 from: http://cms.herbalgram.org/commissione/Monographs/Monograph0226.html

Gumbel D. 1993. Principles of holistic therapy with herbal essences. Brussels, Belgium: Haug International

Henry M L and Harris K S. 2002. LMH official dictionary of Caribbean herbs and medicinal plants and their uses. Jamaica: LMH Publishing

Inouye S, Takizawa T and Yamaguchi H. 2001. Antibacterial activity of essential oils and their major constituents against respiratory tract pathogens by gaseous contact. Journal of Antimicrobial Chemotherapy 47:565-573

Inouye S, Uchida K, Nishiyama Y, Hasumi Y, Yamaguchi H and Abe S. 2007. Combined effect of heat, essential oils and salt on the fungicidal activity against Trichophyton mentagrophytes in foot bath. Jpn. J. Med. Mycol.8:27-36

Jamaica Gleaner. 2004. Herbal medicine renewal WHO issues new recommendations for ginseng, echinacea and other medicinal plants. Jamaica Gleaner March 10. Retrieved April 30, 2009 from http://www.jamaica-gleaner.com/gleaner/20040310/health/health4.html

Jayasinha P. 1999. Lemongrass- a literature review. Sri Lanka: Industrial Technology Institute.

Koffi K, Komla S, Catherine G, Christine R, Jean-Pierre C and Laurence N. 2009. In vitro cytotoxic activity of *Cymbopogon citratus* L. and *Cymbopogon nardus* L. essential oils from Togo. Bangladesh J Phramacol. 4:29-34

Krippner S. 2003. Models of ethnomedicinal healing. Paper Presented at the Ethnomedicine Conferences, Munich, Germany. April 26–27 and October 11–12

Kulkarni R N. 1994. Phenotypic recurrent selection for oil content in East Indian lemongrass, Euphytica 78:103-107

Leite J R, Seabra Mde L, Maluf E, et al. July 1986. Pharmacology of lemongrass (*Cymbopogon citratus* Stapf). III. Assessment of eventual toxic, hypnotic and anxiolytic effects on humans. Journal of Ethnopharmacology 17:75–83

Lorenzetti B B, Souza G E P, Sart S J, Filho D S, and Ferreira S. 1991. Myrcene mimics the peripheral analgesic activity of lemongrass tea. Journal of Ethnopharmacology 34:43-48

Lowe H, Payne-Jackson A, Beckstrom-Sternberg S, Duke JA. 2000. Jamaica's ethnomedicine: its potential in the healthcare system. Kingston, Jamaica: Canoe Press, University of the West Indies

McElroy J L and Albuquerque K. 1985. Small-scale agriculture in the U.S. Virgin Islands, 1930-1983. Proc. Caribbean Food Crops Soc. 20:17-22

Minami M, Kita M, Nakaya T, Yamamoto T, Kuriyama H and Imanishi J. 2003. The inhibitory effect of essential oils on herpes simplex virus type-1 replication in vitro. Microbiol. Immunol. 47:681-684

Mitchell S A, Jagnarine R D, Simmonds R, Francis T, Picking D and Ahmad M H. 2008. A journey through the Medicinal Plant Industry of the Caribbean highlighting UWI Mona's contribution. Caribbean Quarterly 54(3):27-52

Moore R W. 1991. U.S. Virgin Islands agriculture production and structure. 1960-1987. V.I. Agriculture and Food Fair Bull. 5:7-10

Moreira F V, Baston J F A, Blank A F, Alves P B and Santos M R V. 2010. Chemical composition and cardiovascular effects induced by the essential oil of *Cymbopogon citratus* DC. Stapf, Poaceae, in rats. Brazilian Journal of Pharmacognosy 20:904-909

Morton J. 1987. Roselle. In: Fruits of warm climates. Miami, FL., USA: Julia F. Morton, pp. 281–286

O'Connor B B. 1995. Healing traditions: alternative medicine and the health profession. Philadelphia, Pennsylvania: University of Pennsylvania Press

O'Donnell J J, Palada M C, Kowalski J A, Bulbulla A and Crossman S M A. 1995. Evaluation of trees for use as hedgerows in alley cropping. UVI Food and Agric. Res.7:16-18

Onawunmi G O. 1989. Evaluation of the antimicrobial activity of citral. Lett. Appl. Microbial. 9: 105-108

Onawunmi, G O, Yisak W A and Ogunlana E O. 1984. Antibacterial constituents in the essential oil of *Cymbopogon citratus* (DC.) Stapf. Journal of Ethnopharmacology 12:279-86

Opdyke D L J. 1976. Inhibition of sensitization reactions induced by certain aldehydes. Food Cosmet Toxicol 49:32-6

Palada M C and Davis A M. 2000. Growth response of Morinda (*Morinda citrifolia* L.) seedlings to organic and chemical fertilizers. In: Palada M C and Williams M E (eds.) Utilizing medicinal plants to add value to Caribbean agriculture, Proc. 2nd Intl. Workshop of Herbal Medicine in the Caribbean. St. Croix, U.S. Virgin Islands: Univ. of the Virgin Islands, pp. p.158-164

Palada M C, Mitchell J M and O'Keefe D A. 2002. Establishment, early growth and development of Morinda (*Morinda citrifolia* L.) in St. Croix, U.S. Virgin Islands. Proc. 7th Caribbean Urban Forestry Conference, St. Thomas, U.S. Virgin Islands (in press)

Palada M C, O'Donnell J J, Crossman S M A and Kowalski J A. 1994. Influence of four hedgerow species on yield of sweet corn and eggplant in an alley cropping system. Agron. Abstracts 1994:7

Pole S. 2006. Ayurvedic medicine: the principles of traditional practice. Philadelphia, PA: Churchill Livingstone

Rodriques E and Carlini E A. 2004. Plants used by a Quilombola Group in Brazil with Potential Central Nervous System Effects. Phytotherapy Research 18:748-753

Selvi V S, Govindaraju G and Basker A. 2011. Antifungal activity and phytochemical analysis of *Cymbopogon citratus, Sauropus androgynus* and *Spillanthes acmella* Plants. World Journal of Fungal and Plant Biology 2 (1):6-10

Shadab Q, Hanif M and Chaudhary F M. 1992. Antifungal activity by lemongrass essential oils. Pak. J. Sci. Ind. Res. 35:246-249

Shah G, Shri R, Panchal V, Sharma N, Singh B and Mann A S. 2011. Scientific basis for the therapeutic use of *Cymbopogon citratus,* stapf (Lemongrass). J Adv Pharm Technol Res. 2:3-8

Silva C de Bona da, Guterres S S, Weisheimer V and Schapoval E E S. 2008. Antifungal activity of the lemongrass oil and citral against *Candida* spp. The Brazilian Journal of Infectious Diseases 12:63-66

Smith R E. 1993. Food demands of the emerging consumer: the role of modern food technology in meeting that challenge. American Journal of Clinical Nutrition 58:307S-312S

Thomas T and Palada M C. 1994. The marketing of medicinal plants in the Virgin Islands: past, present and future prospects. Hort Science Abst. 29:558

Thomas T. 1997. Traditional Medicinal Plants of St. Croix, St. Thomas and St. John. A Selection of 68 plants. Cooperative Extension Service, Univ. of the Virgin Islands, St.Croix, U.S. Virgin Islands

Tisserand R. 2011. Skin Sensitivity Quenching in Essential Oils. Retrieved on January 10, 2011 from: ec.europa.eu/enterprise/sectors/…/files/…/assoc_3158_atc2_uk_en.do…

U.S. Department of Commerce. 1995. 1992 Census of Agriculture. Vol. 1, Part 54. Virgin Islands of the United States, Area data issued March 1995, Bureau of Census, Washington, D.C.

Viana G S, Vale T G, Pinho R S and Matos F J. 2000. Antinociceptive effect of the essential oil from *Cymbopogon citratus* in mice. J Ethnopharmacol. 70:323-327

Williams L A D. 2006. Ethnomedicine. West Indian Medical Journal 55:215-216

Wood M. 2008. The earthwise herbal: a complete guide to Old World medicinal plants. Berkeley, CA: North Atlantic Books

Zhou J, Xie G and Yan X. 2011. Encyclopedia of traditional chinese medicines – molecular structures, pharmacological activities, natural sources and applications: isolated compounds T-z, References for isolated compounds tcm original plants and congeners. Berlin: Springer-Verlag