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GINGER

Production in Jamaica

TECHNICAL GUIDE

Ministry of Industry, Commerce, Agriculture & Fisheries

GINGER PROGRAMME

Jamaica has a long tradition of producing high-quality ginger with unique chemical compositions that are valued in specialty markets.

The Jamaican ginger is known to be of premium quality on the world market today. Although this popular plant is native to Asia, the Jamaican ginger is by far more pungent and aromatic than the varieties cultivated in other countries. It is positioned in niche markets and it is estimated that there is global demand of about 21,000mt of fresh (4,200mt of dried) produce.

Since the early-1990s, however, the country has been largely excluded from global ginger trade due to the impact of diseases. Influenced by rhizome rot and bacterial wilt diseases, Jamaica's production of ginger declined precipitously from 900 metric tons during the 1990s to 200mt during 2000, and has fluctuated between 200mt and 300mt for much of the last five years, making the country a sustained net importer of the product.

Over the past few years, the Ministry has experimented with the cultivation of rhizome rot and bacterial wilt-free planting material from tissue culture plantlets grown under protected environment. Tissue culture technology helps to minimize effects of the disease through the provision of clean planting material to farmers. This approach has performed creditably and has confirmed the economic and technical feasibility of combating the current disease challenges through the use of these technologies. Buoyed by these findings, the Ministry envisages a transition of the pilot project to a commercial public-private partnership with the same underlying objectives.

GINGER

PRODUCTION IN JAMAICA

TECHNICAL GUIDE

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Table of Contents

Foreword

Jamaican ginger is highly demanded by speciality food manufacturers and flavour extractors in the major ginger-consuming markets based on superior flavour and aromatic principles, as determined by gingerol and zingiberene concentrations.

Despite the substantial market opportunities, production of Jamaican ginger generally declined in the 1990s, excluding the brief period of government price subsidy between 2001 and 2005. The steep decline in production was attributed primarily to the impact of the Ginger Rhizome Rot disease (GRR) on yield, quality, output price, and industry competitiveness. Acreage response during the period of price subsidy spurred marketable output but also introduced the pathogens to uninfested lands.

Based on the aforementioned market opportunities, supply-side constraints, efficacy of the integrated production model in managing the Ginger Rhizome Rot disease, and the need to maintain market presence, the Export Division of the Ministry of Agriculture and Fisheries recently initiated a programme to supply disease-free ginger planting material to the industry as part of a medium- to long-term structural solution.

These efforts resulted in phenomenal performance of the ginger sub-sector, which moved production from 444 tonnes in 2011 to 1,082 tonnes in 2012, by increasing the area under production from 162 hectares (405 acres) to 219 hectares (547.5 acres). These results have been achieved because of targeted interventions by the Ministry in relation to research, supply of clean planting material and other input support, as well as a guaranteed market.

The manual is a guide to current best practices for successfully growing ginger in Jamaica. It is hoped that users will benefit from the information provided, so as to increase production and productivity of the crop, thereby contributing to food and nutrition security and the foreign exchange earnings of Jamaica.

Honourable Audley Shaw, CD, MP.

Minister of Industry, Commerce, Agriculture and Fisheries

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Dermon Spence
Chief Technical Director
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1

Introduction

Zingiber officinale Roscoe is a shade-tolerant, erect, herbaceous, rhizomatus, perennial plant, native to Asia. Ginger is widely grown in Jamaica, and recognized not only as a staple spice in Jamaican cuisine, but with an increasing reputation as a medicinal plant. Its fleshy, finger-like rhizomes (underground stems) are the source of the spice called ginger. Worldwide, ginger is valued as a staple spice by the peoples of the world.

Ginger can be consumed fresh, dehydrated, powdered, or pickled. It is also used in the manufacture of ginger oil, ginger oleoresin or gingerin, and starch. Ginger powder is used in soft drinks, alcoholic beverages, ginger preserves, ginger candy, and ginger pickles. Traditional medicines also use ginger to treat varying symptoms such as nausea, headaches, indigestion, flatulence and colic. In Jamaica, the major ginger-growing areas are 450- 900 metres above sea level, in the hilly areas of the parishes of Manchester, Clarendon, St. Ann, St. James, Hanover, and Trelawny. While ginger grows well in many types of soils in Jamaica, the best results come from clay loams with a good supply of organic matter and proper drainage.

Ginger is thought to have been introduced to Jamaica around 1525. By 1547, the export of ginger has been reported to have amounted to over 1.2 million kg. Prior to 1740, ginger was associated with the Parish of St. Ann, where it had first been planted by the Spanish. Subsequently, the Christiana region in Manchester became well known for its ginger production, when it was recognized that the soil and climatic conditions were especially suitable for the growing of ginger. To date, a 16.1-km (10-mile) radius around Christiana has been identified as the region that grows the finest ginger in the world.

The quality of Jamaican peeled dried ginger has remained the best in the world, commanding the highest prices. Between the 1930s and 1960s, Jamaica was listed as one of the three largest producers of ginger in the world, along with India and Sierra Leone. Since then, ginger production and export have declined significantly due to various factors, including by the impact of the Ginger Rhizome Rot disease complex.

2

Crop Establishment

Varieties

There are four known varieties of ginger in Jamaica. These are:

- The Jamaica Native (Fig. 1) – small, fibrous rhizomes that are very pungent; when cut, they exhibit a rich yellow interior
- The blue or flint ginger (Fig. 2) – medium-sized, pungent, fibrous rhizomes which, when cut, exhibit a bluish tinge
- The yellow or white ginger (Fig. 3) – medium-sized rhizomes that are less fibrous, pungent; when cut , they have a yellow interior
- Hawaiian or Chinese ginger (Fig. 4) – large, plump, fibrous, less pungent rhizomes which, when cut, has a white to cream colour interior with a bluish ring in older rhizomes.

Fig. 1 Jamaica Native Ginger

Fig. 2 Blue or Fint Ginger

Fig. 3 Yellow or White Ginger

Fig. 4 Hawaiian or Chinese Ginger

Growth

The ginger plant has three distinct growth phases. The first phase involves root and shoot development, which occurs within 35 to 45 days after planting (DAP). Under ideal conditions, shoots appear aboveground 10-15 DAP, although this process may be prolonged for up to two months.

The second phase vegetative growth, which is followed by flowering, primarily occurs within the next 150 days, with slow rhizome growth. Flowering usually takes place at the end of this phase, at 6 ½ months. The flowers appear white or yellowish-green in colour and are usually sterile, rarely setting seed.

Fig. 5 Anatomy of Ginger plant

During the next 90 days, shoot leaf growth ceases with rapid rhizome growth; this is the third phase. By 8 months, the shoots typically dry down. Mature rhizomes are usually harvested 8 to 9 months after planting.

Photoperiod plays an important role in the development of ginger rhizomes. Ginger plants may require either short or long day length periods for its growth. As day length is increased from 10 to 13 hours, vegetative growth is enhanced. Vegetative growth is inhibited and rhizome swelling promoted as day length decreases from 13 to 10 hours.

Climate and soil requirements

Ginger is best adapted to warm (29°-32°C) and humid climates for growth. The base temperature requirement is 13°C, with an upper limit of 32°C/27°C day/night temperatures. Temperatures in excess of 32°C can cause sunburn, while low temperatures induce dormancy.

Ginger plants require annual rainfall of at least 1,500-2,000 mm, with a maximum 3,000 mm per annum, evenly distributed throughout the vegetative stage. In the absence of adequate rainfall, irrigation becomes essential. Ginger also requires one month of no rainfall prior to harvest. Although able to grow at sea level or up to 1,500 metres above it, ginger thrives at an optimum elevation of 300-900 metres.

Ginger grows best in well-drained, light to medium textured soils with a good supply of organic matter and a pH between 5.5 and 6.5. Stiff clays and coarse sands and soils with low pH are unsuitable for the cultivation of ginger, as they tend to cause malformation of the rhizomes and poor growth respectively. In soils with high manganese levels, the pH should be between 6.5 and 7.0. The soil should be high in biological diversity with a good balance of beneficial microorganisms.

Fig. 6 Established ginger field

Site selection and preparation

The site selected for ginger cultivation may be in full sun or have partial shade not exceeding 45%. Shading is helpful in reducing water loss and aiding in the general cooling of the plant to prevent sunburn. Plants in full sun will require overhead sprinkler irrigation to aid cooling. The soil should have good drainage and aeration, and be tested for nutrient status, pH, and soilborne pathogens, including nematodes, before planting.

Cultivation of ginger on slopes greater than 40 degrees should be avoided, and the best land husbandry practices must be employed. On hillsides, contour mounds are to be made across the slope. The distance between mounds is dependent on the slope of the hill. These mounds minimize or slow down soil erosion. Contour drains are to be made 10.7 – 12.2m (35-40 ft) apart to facilitate run-off. These drains are to be connected to waterways which will act as catchment areas.

The land should be ploughed to a depth of at least 30 cm (12in.), one to three months before planting, and allowed to weather properly, then be harrowed and furrowed to a refined condition before planting.To avoid water-logging conditions, appropriate drains must be constructed. Approximately 10-15 tonnes of organic manure per hectare should be applied to the soil during land preparation.

Selection of planting material

Rhizomes for planting are selected from disease-free material. It is recommended that second-generation (F_2) seed from tissue culture origin be used as planting material. Seed pieces for planting should weigh between 25g and 50g each, having 2-3 good buds.

Fig. 7 Clean planting material for tissue culture in lab

Pre-plant treatment

The aim of pre-plant treatment of rhizomes is to induce early germination and protect planting material from soilborne pests and diseases. Ginger Rhizome Rot is a serious disease that warrants seed treatment before planting. Hence, seed pieces should be dipped in an appropriate fungicide, such as Dithane M45, Topsin M, or another recommended fungicide, at a temperature of 50°C for 10 minutes to aid in the control of seed-borne pathogens and nematodes. Treated rhizomes are then air-dried in the shade and planted out shortly thereafter.

Planting

Planting is done at the start of the rainy sea son, usually between April and May. On flat land, the normal plant spacing is 23-30 cm x 15-23 cm (9-12 inches x 6-9 inches). This spacing gives 110,000 - 218,000 plants per hectare (44,000-87,000 plants per acre). Sets are placed in furrows 30-45 cm (12-18 inches) deep then covered to a depth of 4-8 cm (1.5-3.0 inches).

On the slope, furrows are planted 80-90 cm (2.5-3.0 ft) apart, along the contour. Sets are placed 20-30 cm (8-12 inches) apart in furrows 30-45 cm (12-18 inches) deep, and covered to a depth of 4-8cm (1.5-3.0 inches).

In small-scale plantings (less than 1 acre), it is recommended that mulching with green manure be applied two to three times during growing season (one at planting, the second at 45DAP and the third 90DAP), as this adds nutrients to the soil. It also assists in controlling weeds and provides desirable conditions for beneficial microorganism activity in the root zone.

Local research has shown that the use of green manure from tree legumes such as Gliricidia sepium can improve yield by 30%.

Fertilizing

Soil analysis is the best way to determine the optimum fertilization regime for the crop. Although ginger is often not fertilized in Jamaica, much higher yields are obtained with fertilization. Ginger is a very nutrient-exhaustive crop, hence application of chemical fertilizer/ or organic manure is absolutely essential.

Ginger plants remove up to 90 kg N/A, 40 kg P/A, and 120kg K/A. The incorporation of fertilizer just prior to planting is important in the initial stages of the crop. Pre-plant application may include a complete fertilizer, additional phosphorus, calcium, or straight fertilizers and organic matter. Nitrogen is supplied as a complete fertilizer NPK ratio of 1:3:1 (eg 10:30:10), 1:1:1 (eg 14:14:14) or 1:2:2 (eg. 11-22-22). Three split dosages are made with 20% as a pre-plant application, approximately 30% of the total N is applied during the first three months and the remaining 50% at five to seven months after planting.

Complete fertilizer applications should be made every two to three weeks up to seven months after planting. Fertilization after planting is made as a side-dress application 25-30 cm (10-12 inches) from the plant row, since ginger is susceptible to fertilizer damage. Complete fertilizer applications are stopped at six to

Fig. 8 rhizome of ginger growing in greenhouse as clean planting material

seven months DAP when flowering begins. Several applications of a potassium fertilizer such as K-mag (00-26) or muriate of potash(0-0-61) are made late in the crop to increase the plumpness of the rhizomes and to produce a shiny skin surface. Micronutrients should be applied as foliar applications of Zn (90.3%) +Fe (0.2%) and Boron (0.2%) at 45 and 75 DAP after planting.

Please note the above recommendations are a guide only, as fertilizer applications should be ultimately guided by the results of a soil test.

Intercropping and Rotations

Intercropping ginger in agroforestry systems such as between rows of coconuts, fruit trees, or rows crops such as pineapples, corn, or beans is encouraged. Compatibility with roots of the intercrop and possible competition for nutrients must be taken into consideration. Hilling of ginger may be problematic in intercrops, hence field arrangements should be amenable to hilling of ginger.

Ginger should not be intercropped with solanaceous crops, including tomatoes and Irish potato, since these crops may contribute to the build-up of soil-borne pathogens such as Ralstonia solanacearum, the causal agent of bacterial wilt in the field. Ginger may be rotated with crops such as corn, scallion, dasheen, or peas. Intercropping and crop rotation improve nutrient cycles and reduce pest levels.

Weed Management Pre-emergence herbicide treatment with herbicides such as diuron at 2kg/A can be used to control weeds in the first three months of crop establishment. Later in the growing season, one or more cycles of manual weeding may be needed. This should coincide with the moulding or hilling, about four to five months after planting. It is best to avoid land infested with nutsedge, as this weed is very difficult to remove, and will pierce the rhizome, forming “nuts” inside them. Further, it may even reduce the size and yield in infested parts of a field.

Irrigation

The water requirement of ginger has been estimated to be between 1320-1500mm during a complete crop cycle. In areas receiving less rainfall, the crop will need regular irrigation. Irrigation is given at fortnightly intervals of 10 days at 90-100 mm/ha in 16-18 irrigations.

Crops must receive approximately 10mm of water every two days during the rapid growth phase. Scheduling irrigation at 60mm cumulative pan evaporation and IW/CPE ratio of 1.0 will produce maximum rhizome yields.

Fig.9 Protected cultivation - ginger growing in Greenhouse

Protected cultivation

Fertigation technology

Protected cultivation systems without soil utilize fertigation technology. In this system, media such as coco peat or coir are used as replacement for soil.

Due to the limited availability of good land to establish ginger, stemming from the large quantities of land currently affected by the rhizome rot disease, this may be a necessary alternative for cultivation of ginger. In this technique, polybags are filled with media, and irrigation and fertilization are done simultaneously via a fertigation system that supplies both directly to the crop roots.

The system is able to reduce the use of fertilizers by supplying fertilizer solution based on each crop's formulation, while distributing the solution to the crops based on their growth levels and needs. This technology can be automated using a timer, thus reducing the labour associated with these tasks.

This technology is currently used in Jamaica for the production of clean ginger planting material under nursery conditions. The electrical conductivity of the fertigation solution should be between 1.8uS and 2,5uS.

Rain shelter structure

A rain shelter has been designed for use in some countries that are exploring protected cultivation of ginger. This may consist of a side-netted galvanized steel frame measuring 30m by 10m wide by 4.5 m high, with transparent polyethylene film (180um thick), roofing, and an insect-repellant netting (0.1 x 0.1mm) side cladding. The entrance must utilize double doors so as to reduce the entrance of insects.

3

Disease & Pest Management

Continuous cropping of the same land is a common practice in Jamaica. This, combined with the use of planting material saved from the previous year, has contributed to the build-up of a number of disease-producing organisms, which have become destructive in many areas.

The main pathogens associated with this disease are the fungus Fusarium spp. and the root knot nematode Meloidogyne sp.. Occasionally, the fungi Rhizoctonia solani, and Pythium sp., along with the bacterium Pseudomonas sp. have been isolated from diseased rhizomes.

Fusarium Yellows and Rhizome Rot

Fusarium Yellows and Rhizome Rot is a major disease of economic importance to ginger production in Jamaica. It has been found in most commercial plantings on the island. Plants infected by the fungus *Fusarium oxysporum f. zingiberi* do not wilt as rapidly as those affected by bacterial wilt. Instead, infected ginger plants are stunted and yellow. The lower leaves dry out over an extended period of time (fig). It is common to find yellow, stunted above-ground shoots among apparently healthy green shoots. The plant finally dries out as the fungus invades the entire vascular system of the underground rhizomes.

Infected rhizomes show a creamy brown discoloration in the water-conducting portion of the rhizome, and a prominent black dry rot of the tissues of the cortex. The rhizomes do not become soft and water-soaked.

Flg. 10 Fusariam Yellow picture

The disease may start in the seed piece originally planted, although it has been observed that the fungus can readily invade wounded healthy seed planted in infested soil as well. As the rot advances into newer rhizome sections, the cortex shows sunken areas. This is especially noticeable on infected rhizomes in storage.

The fungus can be carried in infected rhizomes. The fungus also produces resting structures in the decomposing tissues of infected rhizomes. Therefore, tissues from infected crops remaining in the field serve as a reservoir of the fungus. Once a ginger field becomes infected, the fungus can remain in the soil for many years. While this may not be clearly noticeable in the rhizome at harvest, ginger harvested from fields contaminated with the Fusarium Yellows fungus may be infected, allowing the fungus to continue to destroy the rhizome tissues in storage. This is a dry rot characterized

by collapse of the cortical tissues, occasionally accompanied by a purpling of the infected areas of the rhizome, and a white, cottony mycelial growth on the cut surfaces of ginger pieces. It is recommended that rhizomes from infected fields should not be used as planting material.

Fig 11 Rhizome Rot image

Bacterial Wilt

Bacterial wilt of ginger is a very destructive disease, and has been reported from some commercial ginger-growing areas of Jamaica. The first symptoms of wilt are a slight yellowing and wilting of the lower leaves. The wilt progresses upward, affecting the younger leaves, followed by a complete yellowing and browning of the entire shoot. Under conditions favourable for disease development, the entire shoot becomes limp and wilts with little or no visible yellowing. However, the plant dries very rapidly and the foliage becomes yellow-brown in 3 to 4 days. Young succulent shoots frequently become soft and completely rotted, and these diseased shoots break off easily from the underground rhizome at the soil line. The underground parts are also completely infected. Greyish-brown discoloration of the rhizomes may be localized if the disease is at an early stage of infection, or discoloration may be general if the disease is in an advanced stage. A water-soaked appearance of the central part of the rhizome is common. In advanced infections, the entire rhizome becomes soft and rots (Fig 7). Bacterial wilt of ginger can be distinguished from other rhizome rots of ginger by the condition of the rhizome and the foliage. A better diagnostic feature is the extensive bacterial ooze that appears as a creamy slime on the surface of a cut made in the rhizome or on the above-ground stem of an infected plant. The bacterial wilt of ginger is caused by a strain of *Ralstonia solanacearum.* The strain of the bacteria attacking ginger will weakly attack tomato, pepper, and eggplant. There is a possibility however that under field conditions, the tomato strain could be severe on ginger, and the ginger strain severe on crops belonging to the tomato family. Thus, it is highly undesirable to plant either crop in a field in which the other had been diseased. The bacterium that causes this disease is soil-borne, and also may be carried in infected rhizomes. Usually, bacterial wilt can be spread from diseased to healthy rhizomes with the knife used to cut the rhizomes into seed pieces. New soil can be contaminated with the bacteria by use of contaminated farm equipment, or by irrigation water flowing through infested soil.

Fig. 12 Bacterial Wilt image

Nematodes

Ginger rhizomes can be severely infected with *Meloidogyne incognita,* the root-knot nematode. The nematode affects the market quality of the crop very seriously, but normally does not destroy the rhizomes. Prominent surface galls are not formed in ginger rhizomes as it does in other plants, and in ginger, the external symptoms are usually not observed. In severe infections, the cortex of the rhizomes appears somewhat lumpy and cracked with water-soaked, slightly brown lesions (Fig.13). Mature females of the nematode are found in these lesions. These water-soaked areas below

the epidermis of the rhizomes can be quite numerous in severely infected rhizomes. The nematode lesions can serve as points of entry to common bacteria and fungi, which are otherwise unable to invade uninjured tissues, and the rhizomes may be destroyed in storage by such organisms.

Fig . 13 Nematode damage

Pythium Soft Rot

Pythium sp has been reported as a cause of severe soft rot of ginger in the field. The fungus has been reported to be carried in seed pieces. In Jamaica, this fungus has been isolated from ginger rhizomes showing soft rot. It is possible that under high rainfall and on poorly drained soil, Pythium soft rot of ginger could be a concern. The yellowing shown by the affected plants can be confused with symptoms of Fusarium yellows and with other problems such as mineral deficiencies. The soft rot caused by Pythium does not produce offensive odours, which are characteristic of some bacterial rots.

Fig 14 Pythium Soft Rot

Leaf Spots

Leaf Spot (Fig 15), caused by the fungus Phyllosticta spp., is a minor disease that can cause significant economic losses if not properly managed. In recent years, there has been an increase in the incidence of this disease consistent with the expansion of production and increases in rainfall events. It can cause severe losses if foliage is affected early in the crop. The disease is noticed on the leaves from July to October. The disease starts as a water-soaked spot which later turns into a white spot surrounded by dark brown margins and yellow halo. The lesions enlarge and adjacent lesions coalesce to form necrotic areas. The disease spreads through rain splashes during intermittent showers. The incidence of the disease is severe in ginger grown under exposed conditions. Leaves may eventually die. Fungicides containing Mancozeb provide good control.

Fig. 15 Phyllosticta leaf spot symptoms

Rhizome Scale

Rhizome scale, or turmeric root scale *(Aspidiella hartii),* is an underground pest of the rhizome. It damages the rhizome by sucking sap from the developing rhizome buds; as a result, the quality of infested rhizomes in storage will deteriorate, affecting storage life and marketability. Infested planting material will have poor germination. Infestations are usually observed during the dry season. When infestations are severe, the sprouting of the ginger is severely affected. Adult

females are minute in size (1.5 mm in diameter), circular, and light brown to grey in colour. Females reproduce sexually and asexually. Timely harvesting and discarding of infested rhizomes during storage reduces further spread of the pest infestation in storage.

Fig. 16 Rhizome Scale

Weevils

The yam weevil *(Paleopus costicollis)* is considered a pest of quarantine importance. While not known to cause economic damage at the field level, it can be a troublesome storage pest. Financial losses can be incurred if rejections occur due to interception on ginger exports. The adult female is 3.9 mm long and 1.90 mm wide, while the male is 3.6 mm long and 1.8 mm wide. The body is uniform dull black, while the appendages are reddish brown. The eggs are deposited under the skin of the rhizomes where the larvae emerge. The larval stage has four instars with a sclerotized brown head and white body, which progressively becomes yellow at each instar. The pupa is 3.2 – 4.9 mm long and 1.8–2.5 m wide. The pupa is a typical exarate coleopterous type i.e. pupating without being enclosed in a cocoon. The life cycle is completed within the rhizome. Both adults and larvae feed on the internal tissues by tunnelling. The presence of the weevil can be detected by fine droppings (frass) and exit holes. Damage by the weevil predisposes rhizomes to storage rots and affects the marketable quality of the rhizomes.

Fig 17 The yam weevil (Paleopus costicollis) is considered a pest of quarantine importance.

Control of pests and diseases

To prevent pests and diseases, several things must be done.

- Do not use planting material from infected fields
- Select only healthy-looking rhizomes from healthy-looking plants
- Obtain clean planting material from select nurseries
- Break and inspect inside of rhizomes for off-colour, rot, and nematode lesions.
- Avoid planting on lands which have a disease history
- Treat planting material before planting (see appendix A &B)
- Do not grow ginger for more than two seasons in the same location to avoid build-up of pathogens
- Crop rotation should be practised for three to four years in ginger production systems
- The use of organic amendments in the form of composts or organic mulch will aid in the build-up of soil quality, organic matter, and microbial activity, thus assisting in suppressing soil-borne pathogens.

4

Harvesting & Post-Harvest Management

Fig .18 Freshly harvested ginger

Yields

Average yields in central Jamaica are 13-18 tonnes/hectare (5-7 tons/acre) of green ginger, with yields being lower in sandy soils and for the native type. In India, the main types planted have a similar yield to Jamaica; in Hawaii, a yield of 44 tonnes/hectare (17 ton/acre) has been reported for their larger green ginger types. Fresh ginger produces 20% (one-fifth) its weight as peeled, dried ginger.

Harvesting

Ginger should be harvested after the leaves have dried (seven to nine months after planting) and the ginger root has fully matured. Internal flesh colour should be pale yellow or bluish. Plants mature and turn yellow around October/November, and dry down by December/January. The reaping period is December to May. Fresh market ginger is reaped first, and dried market ginger is reaped nearer May. Delaying harvesting after maturity is reached will reduce rhizome quality, decrease the

storage life, and increase the incidence of sprouting during storage.

Harvest rhizomes carefully by hand using a fork or cutlass to lift and break the soil. Harvesting under very wet or very dry conditions can reduce the ease of operations and increase the level of damage. Transport harvested ginger in field crates from the field to the packing house. Sacks or bags are unsuitable for transport as the level of breakage in sacks is substantially higher than in the field crates, sequentially causing the level of rejection during grading to increase.

Fig .19 Ginger being harvested

Post-harvest handling

Ginger may be successfully stored for up to one year if the correct post-harvest handling and storage procedures are used. Market requirements demand that rhizomes be large and well formed with limited branching. Grading should be carried out in the field to remove rhizomes that do not immediately attain the export specifications. Grading is also required prior to packing to remove rhizomes that were broken or damaged during field transport and handling. Wash rhizomes in water as soon as possible after harvesting, as soil is more difficult to remove when dry. Washing with a high pressure hose, coconut fibre, or a soft brush and plenty of water can give rhizomes a fresh appearance. Care is required during this operation to prevent breakage. After washing, a 10-second dip treatment in 5.25% bleach solution (i.e. two drops of bleach per litre of water or nine drops per gallon) is recommended. This will assist in minimizing microbial damage and may improve presentation. After washing and dipping, rapid drying is required, preferably in field crates in a well-ventilated area. Prolonged periods of drying in sunlight are to be avoided as water loss and shrivelling will occur.

Fig. 20 Graded ginger packed for export

Grading and packaging for export

For the fresh market trade, ginger is loosely packed in layers. Size grading may be carried out in 18kg cartons based on market requirements. For sea shipment, an additional 5% weight is required to account for weight loss during transport. For the dry market trade, ginger is washed, split and dried (12-15% moisture) before packaged in jute bags based on market requirements.

5

Appendices

Appendix A: Pre-plant fungicide treatment of ginger planting Material

Step 1 How to prepare fungicide mixture for treatment of planting material

- Take a small amount of water and pre-mix all the required amount of fungicide in it.
- Pour fungicide solution in the total volume of water and mix thoroughly for at least 5 minutes. Add a commercial sticker at the labelled rate for the best results.
- Prepare fresh stock of fungicide mixture after treating 2000 lbs of rhizomes.
- **Never reuse fungicide solution the following day.**

Fig 21. Pre-treatment of ginger

Step 2 Fungicide treatment

- Fungicide dip treatment should be done on dry, sunny days.
- Use systemic fungicide topsin 70% (a.i.Thiophanate methyl), following the instructions on the label. A 0.2% fungicide mixture is often used.
- Place ginger rhizomes in an onion bag or clean fertilizer bag.
- Make holes in the bottom of the bag to allow for draining of water.
- Dip bag with ginger in fungicide mixture for 20 minutes.
- Make sure that the bag is fully covered by the fungicide mixture.
- Move bag up and down in mixture every five minutes for best results.
- Remove bag with rhizomes and spread on a clean surface to dry.

Appendix B: Hot water treatment for control of parasitic nematodes

Planting material should be washed and surface sterilized with 10% bleach solution before treatment. To treat planting material, dormant seed pieces should be placed in hot water (50°C/120°F) for 10 minutes and then cooled. Seed pieces should be completely dormant or germination will be reduced. Fungicide dip treatments can be done following the hot water treatment. The treated seed pieces should be planted within 2-3 weeks of treatment. Please note thathot water treatment is not effective for other pathogens that may be present in the rhizome.

Fig 22. Setp 1 of dipping treatment ; check temperatrure

Fig 23. Step 2 of treatment ; place material in bag

Method 1: How to dip ginger in hot water

This method requires:

- Two half 200-litre metal drums for hot water
- One drum for cold water
- One or two buckets
- A long thermometer
- Two fires
- Several clean fertilizer bags (onion bags can also be used)
- Sufficient water
- Ginger planting material for dipping

Step 1: Place two of the half drums, each about two-thirds full of water, on the fire. Heat the water in DRUM 1 to 50°C, and the water in DRUM 2 near to boiling point (hotter than the water in DRUM 1).

Cool water is kept in third drum.

Step 2: Carefully select dormant planting material and place in the bag.

Step 3: Place bag at the bottom of DRUM 1 as a cushion and immerse bag with planting material into the water at 50 °C.

Fig 24. Step 3 of treatment; place bag of ginger in drum

- The rhizomes will soon absorb some heat and the temperature will drop nearer to or below 48 °C.
- If necessary, hotter water from DRUM 2 should be added slowly to DRUM 1 to bring the temperature up, to between 48 °C and 50 °C.
- If the water temperature gets to over 50 °C, cool water from DRUM 3 should be added to bring it back to between 48 °C and 49 °C. It soon becomes very easy to keep the temperature steady by adding hotter or cool water, and regulating the fire which should be low at this point.

Fig 25. Step 4 of treatment; stir while checking temperature

Step 4: Dip planting material for 10 minutes. The temperature should be checked every 5 minutes or so. More than one batch of ginger may be dipped by having a third or fourth fire. It is very important to keep the water temperature between 48 °C and 50 °C for the right length of time (10 minutes).

Fig 26. Step 5 of treatment; cool rhizomes on clean surface

The water temperature must be kept constant. Temperatures above those recommended will damage the seed pieces while temperatures below will not effectively control the nematodes.

Step 5: Cool rhizomes on clean surface.

Method 2: How to dip ginger in hot water

Step 1: Prepare fire, drums for cold & hot water, and thermometer for temperature control.

Step 2: Select apparently healthy dormant rhizomes. Discard all seed pieces showing any cracking injury or rot.

Step 3: Place ginger into bags. Place fertilizer bag at the bottom of the drum as padding.

Step 4: Dip seed pieces in hot water at 50°C for 10 minutes. Check temperature of water frequently.

Step 5: Place rhizomes on the clean surface to cool. Treatment can be done a few days prior to planting or fungicide dip treatment.

Appendix C: Estimated Cost of Production of Fresh Ginger per Hectare

Parish	Manchester
Extension Area	Christiana
Crop	Ginger
Crop Maturity	9 months
Reaping Period	3 months
Planting Distance	30cm x 60cm
Planting Density at 0.4 Hectare	21,780
Terrain	Hillside Farm
Land Preparation	Manual
Irrigated/Rain-fed	Rain-fed
Area	0.4 hectare
Man-day Charge (excluding lunch)	$1,200
Projected Marketable Yield (Kg)	10,560
Cost of Production ($/Kg)	$59

Estimated Cost of Production of Fresh Ginger per Hectare

Labour Operations	Unit	No. of Units	Cost/Unit	Total Cost ($)
Land Clearing	MD	2	1200	2,400
Ploughing	MD	40	1200	48,000
Harrowing	MD	20	1200	24,000
Furrowing	MD	20	1200	24,000
Maintaining Trench	MD	10	1200	12,000
Preparing Planting Material	MD	1	1200	1,200
Planting	MD	40	1200	48,000
Weeding	MD	60	1200	72,000
Fertilizing	MD	4	1200	4,800
Harvesting	MD	60	1200	72,000
Lunch		257	500	128,500
Subtotal				436,900
Material Inputs				
* Planting Material				36,000
Fertilizer				14,800
Subtotal				**50,800**
Other Costs				
Transportation (10% of material)				5,080
Contingencies (10% of labour and material)				48,770
** Tools discounted for 5 yrs				7,000
Land charges per crop cycle				5,000
Supervision				73,155
Subtotal				**139,005**
Total Operating Expenditure per Crop Cycle				**626,705**

11

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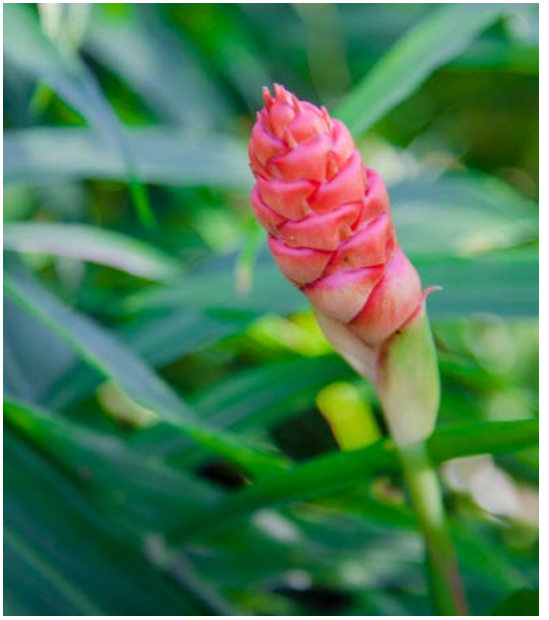

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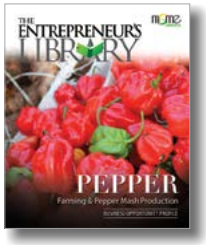

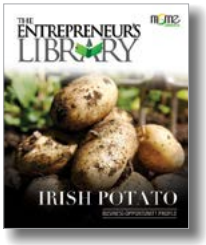

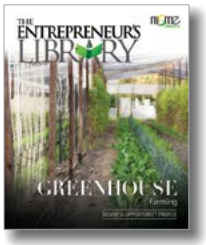

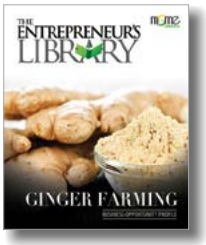

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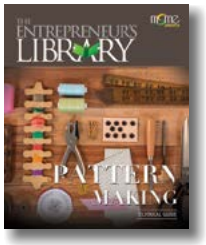

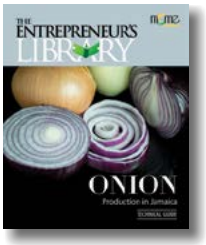

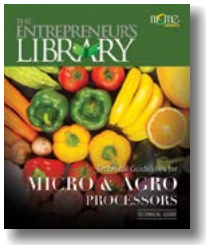

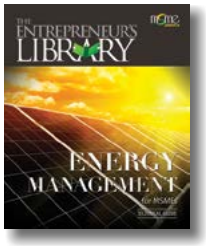

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