What is IICA?

The Inter-American Institute for Cooperation on Agriculture (IICA) is a specialized agency of the Inter-American system, and its purposes are to encourage and support the efforts of its Member States to foster agricultural development and rural well-being in their territories.

With more than six decades of institutional life, the Institute is responding to new mandates issued by the Heads of State and Government of the Americas, the General Assembly of the Organization of American States (OAS) and the ministers of agriculture of the Americas, to reposition itself so that it can meet both the new challenges facing agriculture and the requests for support it receives from its member countries.

As it pursues its vision and mission, the Institute has competitive advantages it can draw on to carry out its new role. It has accumulated a wealth of knowledge regarding agriculture and the rural sector, the diversity of peoples and cultures, and the agroecological diversity of the hemisphere, all of which are important for crafting creative solutions to a wide variety of problems and challenges.

Its presence in all of the Member States gives the Institute the flexibility it needs to move resources between countries and regions, in order to design and adapt cooperation initiatives intended to address national and regional priorities, facilitate the flow of information and improve the dissemination of best practices.

The Institute has its Headquarters in Costa Rica, and Offices in 34 countries of the Americas, as well as an Office for Europe located in Madrid, Spain. The Directorate for Strategic Partnerships works out of the IICA Office in Washington, D.C.

ISSN-0534-5391
CaRC/TT-07/06

Good Agricultural Practices
Shado Beni Production

Compiled by:
Ayoub Mohammed
Agricultural Officer
Ministry of Agriculture, Land and Marine Resources

Wayne De Chi
Agricultural Health and Food Safety Specialist, IICA

IICA OFFICE IN TRINIDAD AND TOBAGO

December 4, 2006

PREFACE

Consumers generally expect the food they eat to be safe. Although individuals can take responsibility for the safety of the food they produce themselves, very few people produce all of the food they consume. This means they must rely on farmers, distributors and processors for the safety of much of what they eat. As such it requires that systems are established to facilitate the safe production of food along the entire agri-food chain.

At the farm level, Good Agricultural Practices are the main requirements for the adoption and application of food management practices for the production of fresh fruits and vegetables without affecting the environment and the lives of farm workers.

This document provides a general guide to the production methods that will ensure the delivery of good quality products.

Aaron H. Parke
IICA Representative in Trinidad and Tobago
and Director of Caribbean Regional Agenda

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Importance of adopting Good Agricultural Practices

Over the past two to three decades there has been an increase in food borne illnesses associated with the consumption of fresh fruits and vegetables (fresh produce). Most of these outbreaks were associated with microbial contamination. The major microbes that have been implicated include *Salmonella, Escherichia coli* 0157:H7, *Campylobacter Listeria monocytogenes* and the *Norwalk* virus. Protozoan type organisms (*Cryptosporidium* sp.) were also implicated in some outbreaks. Nematodes, (*Strongylus* sp.), have also been a source of food borne illness. Traceback studies subsequently indicated that in most cases, breaches occurred during production and postharvest handling which led to produce contamination and illness. In an attempt to reduce these risks Good Agricultural Practices (GAP) Protocols were developed. In 1991, the United States Department of Agriculture (USDA) introduced the first voluntary guidelines whose primary objective was to reduce the microbial population of fresh produce. A European model referred to as EurepGAP was subsequently introduced. The European model, while placing emphasis on microbial reduction, also places great emphasis on integrated pest management and pesticide usage. When first developed GAP was suggested as voluntary guidelines. With the passage of time these guidelines have started to become more important to the fresh produce industry. In the U.S., more companies that distribute fresh produce are demanding mandatory third party independent audits of fresh produce growers as a prerequisite for purchasing. In January 2006, the European Union (EU) is set to implement its pesticide initiative programme a programme directly related to EurepGAP. This measure will have tremendous implications for Caribbean exporters whose products are marketed in the European Union. The International Standardization Organisation (ISO) has developed its food safety standard ISO 22000:2005. Good Agricultural practices are the foundation on which the pre requisite programme is based making GAP even more important to the future of trade in fresh produce.

1.2 Principles of GAP

The U.S. model is based on 8 principles which are also applicable to other models that were subsequently developed. They form a useful basis for implementing any GAP initiative.

Principle 1: Prevention of microbial contamination of fresh produce is favoured over reliance on corrective actions once contamination has occurred.

Principle 2: To minimise microbial food hazards in fresh produce, growers, packers, or shippers should use good agricultural and management practices in those areas over which they have control.

Principle 3: Fresh produce can become microbially contaminated at any point along the farm to food chain. The major source of microbial contamination with fresh produce is associated with human and animal faeces.

Principle 4: Whenever water comes into contact with fresh produce the water's quality dictates the potential for contamination. The potential for microbial contamination from water used with fresh fruits and vegetables should be minimised.

Principle 5: The use of animal manure must be closely monitored to minimize microbial contamination.

Principle 6: Worker hygiene and sanitation practices during production, harvesting, sorting, packing and transport play a critical role in minimising the potential for microbial contamination of fresh produce.

Principle 7: All applicable laws that are aimed at reducing microbial contamination of fresh produce should be obeyed.

Principle 8: Accountability at all levels of the agricultural environment is important to a successful safety programme. Qualified personnel and effective monitoring are critical in ensuring all elements of the programme are operating effectively. This helps to effectively implement traceback through distribution channels if things go wrong.

1.3 Components of the GAP Protocols

The GAP Protocols have identified the major points at which contamination can occur on the farm and during postharvest operations. These points are sometimes referred to the major hazard control points. By following the recommendations aimed at reducing contamination at these points one can significantly reduce the risk of produce contamination. The major components:

- Site selection, topography and land preparation
- Fertilizer application of inorganic and more importantly animal manure
- Worker health and hygiene
- Pesticide safety
- Water quality on farm and in the postharvest environment
- Postharvest operations

2.0 IMPORTANCE OF SHADO BENI IN TRINIDAD AND TOBAGO

Shado Beni (*Eryngium foetidum*) is a culinary herb which has gained significant importance as a crop over the last 12-15 years. It is known by other names including bandhanya and fitweed. On the North American market it is sold as cilantro. Its odour closely resembles that of the more common cilantro. Historically, usage of the crop was confined to small rural communities where it was found growing wild in sugar cane plantations. It was a very common and important ingredient in rural cuisine.

Having recognised its importance as a new crop with tremendous economic potential, the crop is now grown commercially in holdings ranging from 5,000 sq ft plots to half acre holdings. The demand for the crop has extended from rural communities to restaurants, high-end supermarkets and international markets mainly in North America. The pungent herb has become a key ingredient in sauces and marinades and as a garnish.

Over the past two to three years, Trinidadian exporters of this culinary herb have lost a lot of their market share to Central American suppliers. The reasons for the loss in this once lucrative market are many, but continuous problems with high microbial populations and poor quality leaves contributed significantly to this situation. Most Central American suppliers have

established GAP programmes for the majority of their farms that supply international markets. Additionally, they have also paid closer attention to postharvest handling considerations and invested in pre-cooling facilities. In order to regain market share GAP and postharvest management practices must be improved considerably.

3.0 SITE SELECTION TOPOGRAPHY AND LAND PREPARATION

3.1 Site Selection

The GAP Protocols place great emphasis on thoroughly evaluating the history of the intended lands that are to be used in production. Land history allows one to ascertain the possibility of risks to human health if these lands were to be cultivated. A number of pertinent questions should be asked and correctly answered before lands are used in the production of fruits and vegetables. It must first be ascertained whether the land was used:

- as a landfill or as a storage for toxic waste
- as a burial ground for either humans or animals
- to dispose of sanitary waste
- as a pasture
- for mining or for extraction of oil and/or gas
- for the disposal of incineration material
- for industrial waste or mineral residues

Other considerations include whether:

- the land adjacent to the intended production site was used for animal husbandry
- there has been any flooding on the said land
- the land been used as a site for manure storage

Lands which were used for storing toxic wastes or as landfills pose enormous risks to human health if they are used for crop production. Landfills and toxic waste disposal sites are known to have high concentrations of heavy metals and other toxins. High levels of mercury, lead, cadmium and other toxic, heavy metals have been well documented on landfills. In addition,

many landfill sites are known to have dangerously high pesticide residue levels because of indiscriminate and careless pesticide usage to control ants, rodents and cockroaches, and also because of the cumulative effect of dumping pesticide containers over very long periods of time. A good example is the presence of DDT which can still be measured on some landfills that are over forty years old. Lands which were used for storage of sanitary waste, incinerated waste, burial grounds and from which oil and gas have been extracted should be avoided at all costs since the risks associated with these lands far outweigh their benefits. Further, sites used for garbage disposal or as waste management sites may contain decomposing organic material and human faeces. Areas which are prone to heavy flooding are also cause for concern since the flood waters can introduce chemical contaminants and dead animals from other areas. Dead animals in stagnant water create the ideal environment for the proliferation of dangerous microorganisms. The presence of animals is mainly associated with raw manure. This issue is discussed in Section 4.2 of this document.

3.2 Land Preparation and Topography

Shado beni is grown on heavy clays. The crop can be grown year round if sufficient irrigation is available for dry season production and if proper drainage is put in place to prevent water logging in the rainy season.

3.2.1 Soil types and soil amelioration.

Heavy clays are normally acidic with a pH range of 3.5-5.5. Important micronutrients are often low especially available soil calcium and magnesium. Additionally, acidic soils tend to fix soil phosphorus resulting in reduced availability of this important plant nutrient. Drainage is often impeded under wet conditions due to soil swelling and large cracks are observed when the soil dries.

Soil acidity is determined by having a soil analysis done by a reputable soil testing laboratory. By determining the pH of the soil and the exchangeable aluminium the exact liming requirements can be determined. Limestone is critical in reducing the acidity of the soil. High soil acidity (pH 3.5-5) impacts negatively on plant growth for the following reasons:

- Concentrations of the potentially toxic elements aluminium, manganese and iron are increased under acidic conditions because of their greater solubilities at low soil pH.
- High soil acidity inhibits microbial activity responsible for organic matter decomposition.
- The efficacy of certain herbicides especially pre-emergent herbicides is reduced.
- Highly acidic clays are less aggregated which results in low permeability and soil aeration.

Limestone is beneficial because limestone:

- Reduces aluminium and other metallic toxins
- Improves the physical structure of the soil
- Encourages microbial activity
- Increases the availability of phosphorus, calcium, magnesium and other important plant nutrients
- Provides the soil and crop with calcium

Limestone should be applied 8-12 months prior to production in order for it to benefit the soil and reduce acidity.

3.2.2 Land preparation

The crop is grown on flat beds demarcated by box drains. The beds are approximately 4 feet wide and vary in length. Drains are about 18" deep by 18" wide. Raw poultry manure and limestone are broadcast liberally and are mixed with the soil. Seedlings or cut stems are used as planting material. They are planted within 24 hours of manure application.

This practice of liberally using raw manure is not acceptable if one is to be GAP compliant. The fact that shado beni is a quick maturing culinary herb means that it is quite susceptible to contamination with raw poultry manure. This problem is further compounded when irrigation water from dirty water sources is allowed to freely splash onto the crop. Since the herb may be used as a garnish or as a minimally processed sauce, high microbial populations will surely compromise human health. It is no surprise that shipments of shado beni were rejected on entry into the U.S. because of high levels of *E. coli* 0157:H7.

Before using poultry manure the guidelines given in this document pertaining to its use must be followed. In an attempt to reduce the likelihood of contamination through the use of poultry manure, farmers may also consider some other soil ameliorants such as:

- Using a plant-based source of compost such as well-rotted bagasse, rice straw, or spent mushroom compost
- Growing the crop in a sharp sand / bagasse-based grow box system
- Using a sharp sand-based production system

4.0 FERTILIZER USAGE

Inorganic and organic fertilizers are used quite extensively in shado beni production. There are guidelines that have been developed when using both forms of fertilizer that prevent risks to human health and safety.

4.1 Inorganic Fertilizers

Much research is still needed in the area of fertilizer requirements for shado beni. What is known is that the crop is a very heavy feeder. The following recommendation is given only as a guide. If a soil test indicates that a different regimen should be used, the recommendations given by the soil testing facility should be used in preference to what is given here.

At transplanting: Apply 5 grams of 12:24:12 to each plant. Repeat this application 7 days later.

After three (3) weeks: Apply 10 grams of Calnitro per plant.

Apply Urea or Sulphate of Ammonia and Calnitro on a weekly basis.

Apply foliar applications of 20:20:20 on a weekly basis for the duration of the crop.

4.2 Organic Fertilizers

Organic fertilizer can be derived from both plant and animal material. The use of animal manure is far more common during the production of shado beni than the use of composted plant material. Animal manure may be derived from poultry, small and/or large ruminants including sheep, goats, diary and beef lot operations, pigs and horses. Of all these forms of manure, poultry manure is by far the most common source of animal manure used in our production systems.

The danger with the use of animal manure is, in almost all cases, these forms of manure are applied raw onto the fields. Animal manure has been well associated with major outbreaks of food borne illnesses worldwide. Animal manure is known to contain very high levels of dangerous microorganisms that can result in human illnesses. These include *Salmonella*, *E. coli* 157:H7, *Cryptosporidium spp.* and the tetanus bacteria, *Clostridium tetani.* In addition, it can be a major pollutant to surface and ground water and to the atmosphere, and is a major contributor to algal bloom on surface water. For these reasons untreated animal manure used in the production of edible produce implies a greater contamination risk to human health and is not recommended. Animal manure may constitute an important source of plant nutrients if it is properly treated (i.e composted) before application onto the field. If the manure is inadequately decomposed then the risks will far outweigh the benefits, thus the need for proper composting. It is also important to fallow the land even when composted manures are used in order to further prevent the possibility of pathogen build up.

4.3 Treatments to Reduce Risks

4.3.1 Composting

Composting is a natural biological process by which organic matter is decomposed. Bacterial and fungal organisms ferment organic matter reducing it to a biologically stable material referred to as humus. Fermentation generates a substantial amount of heat and this heat reduces and in some cases eliminates the biological hazards. Composting treatments may be divided into two categories: passive composting and active composting.

Passive composting is simply taking the animal waste placing it in a pile and covering it. Over time microbial activity will decompose the material and the heat generated will destroy the dangerous microorganisms present. This method has the advantages of being simple to do and costs very little in terms of labour. Passive composting is; however, very dependent on ambient temperature and takes 4-6 months before the manure is sufficiently decomposed and safe to use.

Active composting is more labour intensive but results in the material being ready for application into the field 4-6 weeks after decomposition begins. Active decomposition is achieved by making a pile consisting of several layers of different organic material. A formulation is given for 1000 kg of fresh animal manure.

Composting materials

To create 1000 kg of fresh animal manure

- 1000 kg fresh manure
- 150 kg dried grass, bagasse, corn stalk etc.
- 50 kg sieved soil
- 10 kg ground charcoal
- 45 kg limestone
- Activator 5kg molasses or sugar mixed with baker's yeast
- Clean water
- Turning instruments
- Water hose
- Thermometer

4.3.2 Other methods of treating manure

A number of available and evolving technologies can be considered in treating animal manure. The use of biogas digesters greatly reduces the foul odour from the manure making it more comfortable for operators to compost the product thereafter. The methane gas can be trapped and

used for other farm operations.

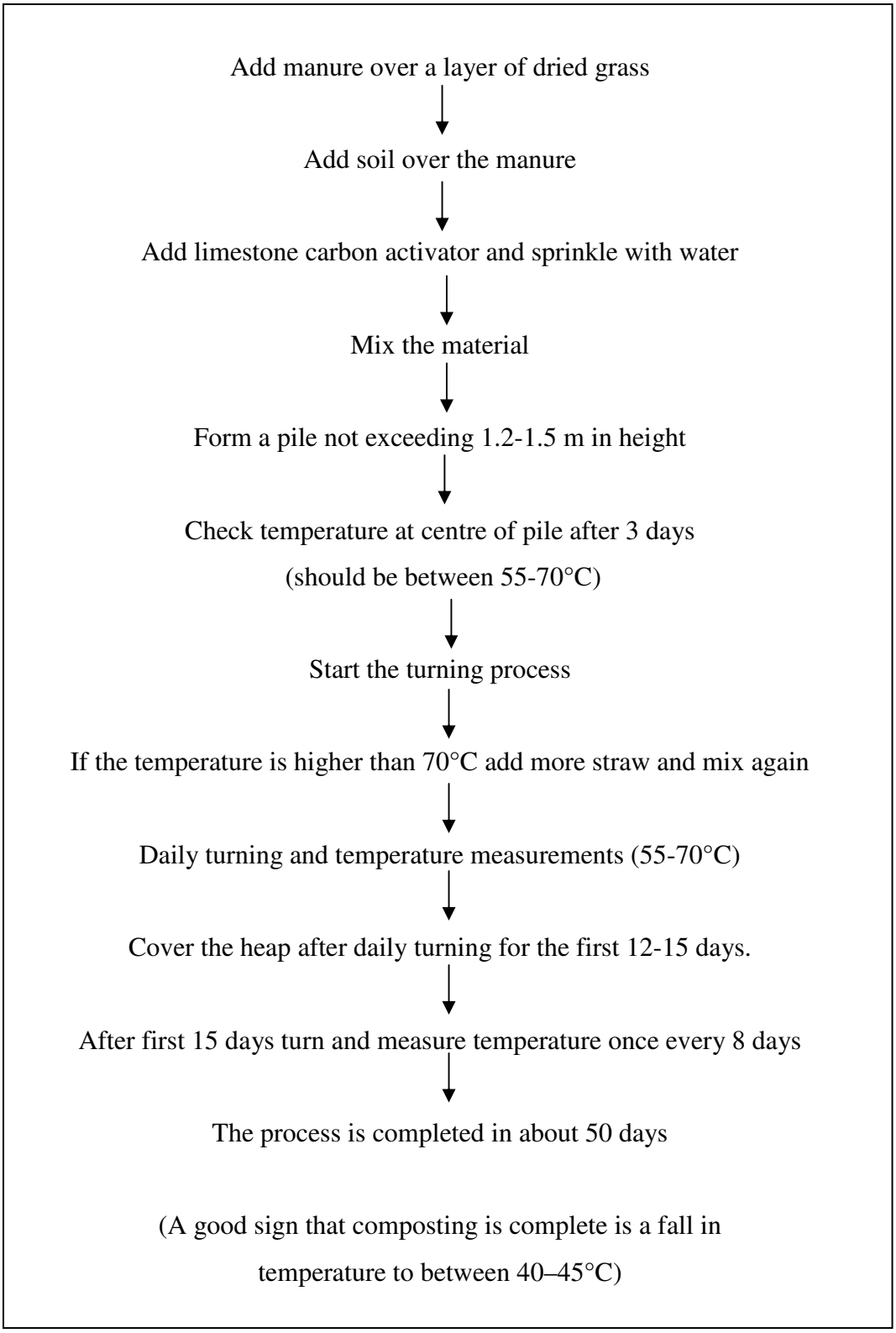

Figure 1: Steps in active composting

Manure pasteurisation is a new technology that has the potential to destroy harmful microbes. In some systems, manure is dried in layers 3-5 cm thick in open sunlight. The dried manure is then subject to composting producing a product that is free of harmful pathogens.

4.4 GAP in the Management of Organic Manure

Good agricultural practices are critical to the safe use of organic matter. It is necessary to observe GAP when using organic fertilizers. The major components of GAP management for organic matter are:

- proper treatment of the material
- storage of the organic matter
- proper field application
- minimising risks to workers
- record keeping and control

4.4.1 Storage of animal manure

There are some key considerations when selecting storage areas where manure is to be stored and treated. Storage areas:

- Must be kept far away from production areas
- must be contained by brick walls, soil piles etc. in order to prevent contamination by rain wash, subterraneous water flow or wind spread
- Store manure on cement floors
- Must be covered to protect against rainfall. Rainfall generates liquid with a huge bacterial population which can contaminate production areas
- Should be covered and prevented from being contaminated by birds and rodents
- Should be kept away from waste disposal areas

4.4.2 Application of treated manure to the field

Once the manure is properly composted it should be tested for its microbiological safety before it is applied to the soil. It should be applied 2-3 weeks before planting. The risk of contamination is further reduced if the treated manure is applied into the planting mounds on cambered beds and

properly mixed with the soil. The common practice of broadcasting raw manure onto the entire field is not recommended.

4.4.3 Hazard to operators

Personnel who handle raw manure must be vaccinated against tetanus. No one with exposed wounds should be allowed to handle manure. After handling raw manure and compost, proper washing ensures prevention of illnesses of workers.

4.4.4 Record keeping and controls

Keeping records of preparation and application of fertilizers are all part of the GAP programme. The information recorded should include the following:

- origin of the organic material
- date composting started and when completed
- temperature recorded during turning
- the physical make up of the composting material
- persons involved in the application
- microbial testing and clearance for usage

5.0 WATER QUALITY

Water quality is an important factor influencing the microbial contamination of fresh fruits and vegetables. The extent to which contamination might occur is also dependent on a number of factors including the stage of development of the crop, the type of crop, time since the last application of water, the manner in which water is stored and handled. Water is essential for a number of operations carried out on the farm including irrigation, pesticide application, fertilizer application and post harvest washing. Additionally, water is required for washing and bathing of farm and packing workers and for drinking. Poor quality farm water can be an important vehicle in microbial contamination of fresh produce.

5.1 Irrigation Water

Critical to the growth and development of shado beni is proper irrigation and drainage. Severe periods of drought will result in poor yields.

5.1.1 Overhead irrigation

A common form of artificial irrigation system is overhead irrigation. Water is sourced mainly from surface water (rivers, streams etc) which is then pumped into polyvinyl chloride (PVC) or galvanise conduits. Water is applied in circular bands over the entire field as a fine mist. Given the levels of pollution, contamination, with harmful microbes, agro-chemical pollutants, human and animal faeces and heavy metal contamination this form of irrigation coupled with splashing of raw manure pose severe risks to human health. Some systems employ the use of irrigation tapes which are used to apply water directly onto the bed. Again the concern is the level of water contamination at the water source. The photograph shows the ease with which irrigation tapes can be permanently employed.

Figure 2: Irrigation tapes used during production

5.1.2 Splash irrigation

Some farmers use simple watering cans or containers to splash water stored in box drains located on the side of the bed. The water is also drawn from polluted surface water and poses the same risks as outlined above.

5.2 GAP in the Prevention of Water Contamination

5.2.1 Precautions to prevent water contamination

- Identify the primary and secondary sources of water and be aware of the possibility of contamination.
- Ensure that livestock effluent is not an additional source of contamination.
- Be aware of wildlife presence and treat water accordingly.
- Do not store manure in production areas.
- Identify soil topography and rainfall patterns and their possible effect on water contamination.
- Verify water acceptability by periodic testing.
- Store potable water in covered tanks.
- Treat pond and other irrigation water-holding receptacles periodically.
- Choose irrigation systems that prevent water from wetting the entire plant.
- Identify and control the risk of water in packing facilities. Cool drinking water must be available for workers. In some cases where it is not possible to have water from contamination from adjacent fields.

5.2.2 Water harvesting and storage

Contaminated farm water is an issue that requires urgent attention. Contaminated shado beni will not be fit for human consumption if this issue is not addressed. On international markets where testing is done on an almost routine basis, rejection and subsequent loss of market share will result. Water harvesting, storage and treatment provide the best long term solutions to these problems. Several countries including some of the poorer nations of the world are turning to systems that facilitate the collection of rain water in concrete ponds, metal or concrete cisterns, or high density polyethylene collapsible cisterns. Rain water, if properly collected and stored, will carry substantially less harmful microorganisms than contaminated surface water. Rain water will require less disinfection than surface water.

5.2.3 Improving surface water

Most Caribbean islands still have relatively uncontaminated surface water sources. Care must be taken to prevent polluting this scarce but valuable resource. In cases where the only available water source is surface water which may not meet the requirements for irrigation, a disinfection regime must be implemented to allow such water to be used for irrigation purposes.

In order for this water to be used it must first be tested to determine the level of microbial contamination. It is recommended that the water be pumped and stored in concrete ponds or cisterns etc. Attaching the pump to a filtration system at source will reduce the amount of organic matter and so improve the efficiency of disinfection especially chlorine-based disinfection. After testing, the stored water is now subjected to a disinfection treatment using a chlorine-based sanitizer. The water is then tested again to ensure it is safe for farm use. Once the water is determined to be safe for irrigation, recontamination must be prevented.

New technologies are now being developed and commercialized that do not require the use of chlorine. Infrared treatment pumps which use a beam of infrared light to destroy microorganisms have been developed. Such technologies are available but have not as yet been tested in our environments.

5.3.4 Potable water

A ready and available source of potable water must be present at all times on the farm and during postharvest operations. Potable water is to be used for all hand washing, showering, produce cleaning, pesticide mixing and other agro-chemical applications. Cool drinking water must be available at all times to all workers even if it has to be bottled and kept in ice. In order to prepare shado beni for market the leaves must be washed and sanitised using a chlorine-based sanitizer. During washing, there is direct contact of water on the surface of the leaves and it is critical that this water meets the standard for potable water. Proper washing of the leaves is an essential step before chlorination since chlorine is ineffective when it comes in contact with organic matter and soil.

Chlorine is used to prevent cross contamination and will not sterilise the product. Effective cleaning and low microbial load of incoming leaves will greatly improve the efficacy of chlorine. Chlorine is normally applied at the rate of 75-100 ppm at a pH of 6-7.5. When used properly, chlorine can significantly reduce microbial populations (between 100-1000 fold reductions).

Figure 3: Surface water surrounded by potential contaminants

Figure 4: Galvanise conduit pumping polluted water into production fields

6.0 AN ALTERNATIVE SYSTEM FOR PRODUCING SHADO BENI

Given the propensity for contamination using the present system an alternative system is proposed for shado beni cultivation. The use of contaminated water and animal manure may have been the primary reason for *E. coli* contamination responsible for confiscation of the herb out of Trinidad by U.S. authorities in the past. The components of the present system are:

- sharp sand
- concrete blocks

- food grade plastic water storage tanks
- polyvinyl chloride (PVC) lines
- check valves
- dissolved fertilizers

Two separate water tanks are needed, one for storage of clean potable water and the other for mixing and storing fertilizer. Fertilizers are applied as a liquid and its application in this form is sometimes referred to as fertigation. Each tank is connected to the beds filled with sharp sand via a system of PVC conduits plumbed into a series of PVC irrigation lines which have holes drilled 10 inches apart. Separate connections are made for water and fertilizers and each tank is regulated using a system of colour coded valves.

6.1 Beds (Dimension and Filling)

The beds are generally made 30 feet in length and 5 feet wide. The beds can be longer but the width is kept at 5 feet in order to ensure that maintenance and crop husbandry practices can be easily carried out. The beds are made by containing the sharp sand in unplastered concrete blocks. Plastering the blocks will result in drainage problems after heavy rainfall and one would need to put in weep holes. It is much easier to use unplastered blocks. Most growers who adopt this system of production use a concrete base rather than placing the concrete blocks on bare soil. The blocks are placed on a concrete platform about two inches above the floor.

6.2 The Fertilizer Blend

The system hinges around a fertilizer blend dissolved in water. For a 100 U.S. gallon capacity tank one would need the following quantities of fertilizers accurately weighed:

- 16 ounces 12:12:17:2
- 8 ounces calcium nitrate
- 5 ounces magnesium sulphate (Epsom salt)

6.3 Fertilizer and Irrigation Regime

Before transplanting, the beds are fertigated with the fertilizer blend for 30 seconds. The seedlings are then transplanted. The fertigation / irrigation regimen is as follows:

Fertigate for six days once per day by allowing the fertilizer to run through the drip lines for 15-20 seconds. On day 7 irrigate with potable water. This facilitates leaching of excess fertilizers from the beds. The cycle is then repeated starting with fertigation.

Figure 5: Separate tanks used for irrigation and fertigation are clearly marked.

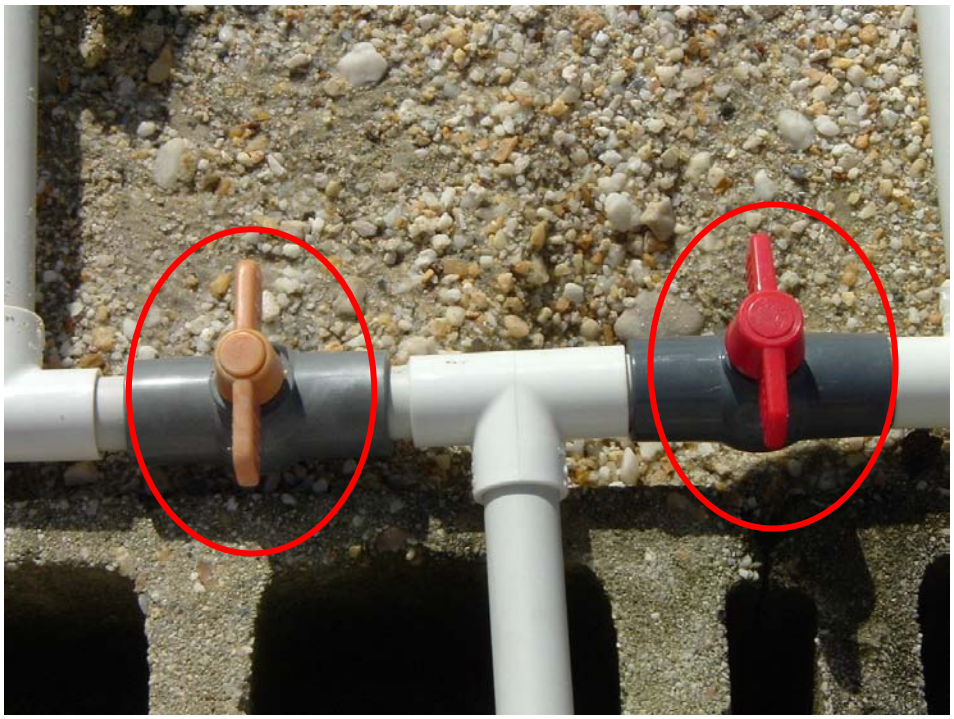

Figure 6: Colour coded valves separate water flow from irrigation flow

Figure 7: PVC lines along the bed

7.0 WORKER HEALTH AND HYGIENE

Workers can be a source of contamination if one does not ensure that the conditions under which they work reduce the opportunity for produce contamination. Contamination can occur both in the field and during postharvest handling operations. Humans can be a major source of pathogens in our food supply. Poor hygiene has been attributed to major food borne illnesses. Personal hygiene refers to practices that promote human health and general cleanliness. Good worker hygiene during production and harvesting will significantly reduce microbial contamination. For this reason, worker health and hygiene must be made a priority on the farm. The following protocols must be established and maintained:

- A food safety training programme must be put in place with periodic training of all farm workers and those who work in packinghouse facilities.
- All workers and supervisors must practise good personal hygiene.
- Field workers must have easy access to clean toilet facilities with proper hand washing equipment.
- All supervisors must be aware of the symptoms of food borne illnesses.
- Sick employees should be reassigned to duties where they are not in direct contact with produce.
- All sanitation practices that are to be followed must be written in a sanitation manual as part of Good Manufacturing Practices (GMP).

All training must emphasize the relationship between poor hygiene and poor food handling and how these practices impact on human health. Managers and supervisors should not take it for granted that employees understand the importance of good personal hygiene. Workers must be trained in all aspects of health and hygiene as they relate to safe food eg. proper hand washing techniques and proper use of toilet and other sanitary facilities. The importance of reporting illnesses to supervisors must be reiterated since many farm workers may not on their own accord report such illnesses to their superiors.

Effective hand washing procedure

- Wet hands.
- Use soap and rub hands vigorously together for a minimum of 20 seconds to ensure lathering.
- Wash the entire surface of the hand, scrubbing it, including the back of the hand.
- Rinse thoroughly with running, clean, potable water.
- Dry with paper towels.
- Close water faucet with paper towels.
- Open the exit door with paper towel and dispose of towel properly.

When should hand washing be carried out?

- at the start of each work day
- after touching or scratching the skin
- after sneezing or coughing
- after handling dirty equipment or utensils
- before starting to pack or process fresh produce
- after each break
- after handling manure or garbage
- after using toilet facilities
- after handling fertilizers, pesticides ,chemicals or cleaning material
- after smoking

It may not be necessary to train your workers in a formal classroom setting. A one-on-one approach may be more appropriate and can remove some of the fears associated with formal classroom-type training. A training schedule that ensures all workers are trained and retrained goes a long way in ensuring greater compliance with personal hygiene practices In some countries, farmer training facilities offer food safety training and this opportunity should be grasped when it is available.

Other strategies that reinforce hygiene and worker health:

- Place signs at strategic locations to serve as reminders of what is expected.
- Teach employees that uncovered sneezing can contaminate fresh produce.
- Use gloves made of impermeable material.
- Encourage workers to start each day with clean clothing.
- Keep dirty boots and clothing away from fresh produce.
- Do not allow workers to smoke or eat in the fields - saliva could spray onto the produce.
- Encourage workers to use break rooms rather than sitting on the floor or around the facilities.
- Have a well-stocked first aid kit which is replenished on a timely basis.
- Train team leaders and other members of staff in basic first aid.

8.0 CROP PROTECTION

8.1 The Basic Approach to Crop Protection

The protection of crops against pests, diseases and weeds could be achieved by employing non-chemical methods. Where appropriate, the use of biological, physical and cultural methods should be employed with minimal reliance on pesticides. The basic elements of crop protection are:

Prevention: indirect measures to reduce pest, disease and weed infestation e.g.

- choice of crop/variety appropriate for the location
- use of crop rotations
- use of disease and pest resistant varieties
- mechanical and physical methods of crop husbandry
- good fertilizer and irrigation practices

Observation: methods to determine when action is required e.g.

- routine crop inspection and pest monitoring
- use of diagnostic and forecasting systems (traps, tests)
- use of decision support systems (literature, computer aided devices)

Intervention: direct measures to reduce pests, diseases and weeds to economically acceptable levels e.g.

- cultural and physical control (e.g. mechanical weeding, traps)
- biological controls (beneficial insects, mites, nematodes, BT and viruses)
- chemical control (insecticides, fungicides and herbicides)

8.2 Integrated Pest Management (IPM) Programmes

In all IPM programmes there are seven (7) major components to consider:

- identification of the causes of crop damage
- determination of the factors which regulate pest numbers and plant health
- monitoring of pest populations, their natural enemies and the environment
- determining unacceptable levels of pest damage
  - a decision making framework which uses all available relevant information to determine the actions to be taken
  - implementation of control measures for the selective manipulation of the pest problem
  - further monitoring and assessment. Record keeping.

IPM programmes combine chemical, cultural and biological practices into one programme to control pest populations. Pesticide applications are carefully timed and combined with other pest management practices to reduce the need for frequent pesticide applications. The pest is identified and quantified, the damaged assessed and the pesticide application is made only when needed, using the recommended rate for adequate control. Minimizing the amount of pesticide used, reduces costs and helps protect the environment.

8.3 Pesticide Use and Misuse

The application of chemical compounds to protect and enhance crop yield is a common practice worldwide. Pesticides are chemicals used to destroy all kinds of pests. Depending on the target organism pesticides are classified as:

- insecticides-used to kill insects
- herbicides-used to kill undesired plants
- fungicides-used to kill molds

Pesticides can be extremely dangerous to human and animal health if they are not handled properly. They represent a chemical hazard for workers in the fields, for persons exposed to them and for the consumers of fruit, vegetables and root crops contaminated by inappropriate treatments.

8.4 Selection of Pesticides

Choosing the appropriate pesticide is very important to the implementation of an effective pest management programme. This will also have a direct bearing on the hazards to which the user and other persons and the environment are subjected. Before selecting the pesticide, the pest should be identified and a decision taken as to whether the pest problem is of economic importance, and/or has the potential to become a problem.

Pesticides should be used only when needed and only in amounts that will adequately control pests. The pesticide used must be recommended for the purposes or crops that it was approved for and under authorized conditions, doses and intervals. It is recommended that growers document and verify that the pesticides used come from certified distributors and that competent authorities approve their usage. Table 1 below gives a list of pesticides used for the production of shado beni.

Table 1. List of pesticides used in the production of Shado Beni

Herbicide	Pesticide/Fungicide
Gramoxone® Round Up®	Rovral Flo

8.5 Pesticide Handling

Pesticide handling should be controlled through every phase of use, from acquisition through to storage and use in the fields. It is important that the persons in charge of handling pesticides carefully follow the instructions for use printed on the label or on the information page that usually accompanies the product, before the product is purchased, used or discarded. It is important to understand proper handling procedures to assess the impact that the pesticide can have on the surroundings and ground water at the application site.

Additional recommendations for producers handling pesticides include the following:

- Have responsible, well-trained personnel handling the pesticide
- Provide the necessary safety equipment to personnel handling or applying pesticide
- Avoid damages to pesticide containers in order to avoid seepage
- Clearly label containers, transfer equipment and application devices
- Avoid changing product containers to avoid confusion and misuse
- Keep a first aid guide and train personnel to respond to an emergency or accident
- Always have a first aid kit available

8.6 Pesticide Application in the Field

The main pesticide-related hazard for people who work in the fields and surrounding areas lie in the possibility that these substances will harm them through direct contact. These substances can come in direct contact with people through:

- inhalation
- absorption through the skin and eyes
- ingestion
- indirect contact exposure

Pesticides can be applied in liquid, solid or gaseous forms. It is important to have instructions for the preparation, mixing, loading and handling of the specific pesticide being used and the actual conditions of use. The amount of pesticide concentrate needed to treat a specific site should be carefully calculated. Staying within the rate stipulated on the label can help to minimize disposal problems associated with excess mixture and can help prevent ground contamination and/or infiltration into water courses.

8.7 Pesticide Storage

Storage areas for pesticides should be clearly marked. Pesticides are poisons and should be treated as such. Proper storage is essential, not only to ensure a safe working environment, but also to assist in dealing with fires and spillage.

Storage sites should be away from other operations and in a location where in case of an accident, there will be no contamination of water or areas that humans frequent. Storage areas should have concrete floors with smooth finishes and drainage to a sump or other holding area where contaminated water can be decontaminated before release. Storage areas should be dry and well-ventilated.

Pesticides must be stored in originally labelled containers with labels plainly visible. Pesticides must not be stored near food, feed or other items which may become contaminated by spilled material, volatile pesticides, and odours.

There must be no smoking, eating or drinking.

An adequate number of appropriate fire-fighting and safety equipment of appropriate capacity in good working condition should be available in the storage area. Pesticides should be separated into product types (insecticides, herbicides, fungicides etc.) and separate stacking areas allocated for each type. Solid products should be separated from liquid products by segregate stacking.

The storage building should be locked to prevent theft and to prevent unauthorized persons especially children from entering. All operating personnel should be thoroughly familiarized with the use of fire fighting and safety equipment and regular practice drills should be conducted.

8.8 Pesticide Residues

Pesticides residues on crops may be hazardous to humans who eat the product. Pesticides do not necessarily cause illness immediately after consumption. However, the periodic ingestion of small amounts of pesticides over extended periods of time can cause many health problems. For this reason high residues on fresh produce are considered as a chemical hazard to consumers. Removal of excessively high pesticide levels from fresh produce is not practical. Therefore the best solution to pesticide contamination is to prevent it from occurring. In the case of agricultural products to be exported, maximum pesticide residue limits for the importing country must be carefully considered. It is therefore important to test the harvested product for unacceptable levels of pesticide residues. These tests can be carried out by chemical analyses in a

certified laboratory.

8.9 Pesticide Disposal

The method of disposal of pesticides must be adapted to the facilities available and the prevailing conditions so as not to create problems of human exposure or environmental pollution. One way to avoid disposal problems is to plan carefully - buy and mix only what is needed. If extra pesticide has been mixed it should be sprayed unto another approved crop on the pesticide label. If it cannot be used, it has to be disposed of by diluting the surplus and emptying the contents where it will do no harm.

Empty pesticide containers should not be used to store food, feed or seed. If possible, they should be returned to the agent. Never dispose of pesticides or pesticide containers in discarded wells or near water sources. Empty, rinsed, pesticide containers can be disposed of at the most sanitary landfills. Pesticide containers may be divided into two types:

- containers that will burn-these are usually made of wood, cardboard or paper. Rinse the container several times with water or oil whichever is the more convenient solvent for the pesticide formulation.
- containers that will not burn-these are usually made of glass, plastics or metal. These should be returned to the manufacturer. Containers that have been used to store mercury, lead or other inorganic pesticides should never be burnt.

8.10 Training and Documentation

The training of personnel responsible for application of pesticides is very critical. They must be aware of the dangers that can occur from the improper use of the pesticides. Safety equipment and knowledge of application devices are important issues. Field workers should be reminded that adverse health effects caused by pesticides are often not noticeable in the short term, but can develop over time where they will become tragically apparent.

8.11 Weed Control

Weeds compete with the crop for light, water and nutrients. If not properly managed, weeds can reduce yields and quality and harbour insects and diseases. Also weeds present in the crop can

make harvest difficult.

The use of herbicides can be costly and if not done properly, can cause crop and environmental damage. The grower should aim to plant his crop in a field that is virtually weed-free. Hand weeding during crop growth is recommended.

Weeds should be controlled continually until the crop leaf canopy is sufficiently large to assist in suppressing weed growth. On sloping land, weeds should be slashed and left in place. This provides ground cover, which in turn prevents erosion of top soil and enhances moisture conservation.

Chemical control of weeds is usually the common practice. Contact and systemic herbicides (Table 1) are most regularly used. Systemic herbicides should only be used as pre-emergents for weed control in shado beni. Strict adherence to the recommended herbicide rate is important. Protective gear should always be worn during mixing and application of herbicides.

Good agricultural practices should aim at reducing the use of herbicides considerably by:

a) identifying and targeting hardy weeds
b) manual methods of weed control
c) frequent use of mechanical weed machines
d) mulching

8.12 Pest and Disease Control

Pest and Control

There is no recorded major pest of economic importance attacking shado beni in the Caribbean.

Disease Control

Web Blight, *Rhizoctonia solani* is the only recorded fungal disease of economic importance affecting Shado beni in the Caribbean. A fungus that appears as water-soaked areas on leaves may start on leaves near to the ground. Affected areas become dark brown and slimy, but later

may dry out. Thread-like fungal symptoms can be seen on the underside of leaves. The disease is promoted by moist conditions.

Root Knot Nematodes *Meloidogyne incognita*

Table 2. Major Diseases of Shadow beni and their Chemical Control

Common Name	**Control**
Rhizoctonia solani	Rovral Flo
Root Knot Nematodes	Mocap 10G

9.0 POSTHARVEST HANDLING: MAINTAINING QUALITY AND ENSURING FOOD SAFETY

Shado beni is a highly perishable culinary herb. Because of its high surface area to volume ratio it loses moisture rapidly under high temperatures resulting in shrivelling and loss of flavour. Unlike some of the other culinary herbs the crop has extremely volatile essential oils which quickly evaporate under poor temperature management.

While no internationally accepted standard has been developed for the herb there are quality indices which have been demanded by buyer. These include:

- dark green undamaged, large leaves
- leaves should be free of soil and residues banned or restricted pesticides
- leaves should be free of visible symptoms of shrivelling
- leaves must show no yellowing (indicative of either over maturity or exposure to ethylene)
- leaves must have high pungency typical of the odour of shado beni
- leaves must have no shot holes indicative of insect damage

The key steps involved in maintaining quality as outlined above are as follows:

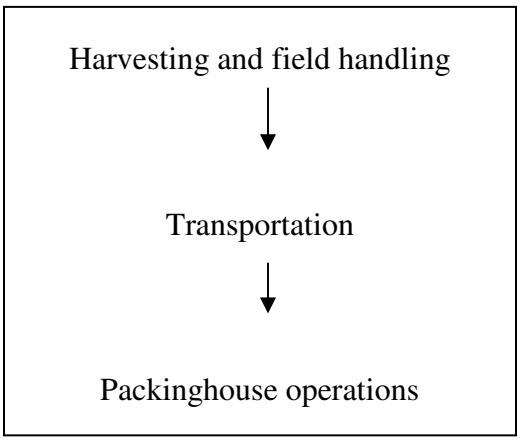

Figure 8: Key postharvest operations

9.1 Harvesting, Field handling and Transportation

The herb should be harvested at the correct stage of maturity. Indices of maturity include:

- Time from planting: Leaves mature in 4 $^{1}/_{2}$ - 6 weeks after transplanting.
- Dark green leaves: Immature leaves are light green.

The crop should be harvested early on mornings when it is very cool and when the leaves are most turgid. Proper irrigation scheduling is also critical in ensuring the turgidity of the leaves. Leaves are cut at the base using a sharp knife. The leaves are removed as a cluster and placed in shallow, light-coloured sanitized harvesting crates. Dark coloured crates will absorb heat and reduce the saleability of the crop. Sanitising the containers ensures that the containers do not themselves cause cross contamination. The crates are subsequently placed in a cool area of the field, preferably in a covered shed. In fact, at all times crates should be kept in a cool area of the field shaded from direct sunlight. Exposure of harvested leaves to sunlight will result in quality loss from as early as 3-6 hours after harvesting. A very common practice is to tie cut leaves into larger bundles using pieces of cloth. This practice should be avoided as it causes breakage of the leaves exacerbating moisture loss and reducing shelf life.

The leaves should be transported on vehicles fitted with a tarpaulin tray. Wetting the tarpaulin cover with clean, potable water before transporting out of the field also helps to provide a cool microclimate for the leaves. Where the journey to the packinghouse exceeds 30-40 minutes it is quite useful to cover the crates with damp clean cool cloth. Sanitising the cloth with chlorine (100 ppm) prevents cross contamination of the leaves.

9.2 Sanitising Harvesting Crates

High density polyethylene crates can be easily sanitized. Sanitization will significantly reduce the risks associated with cross contamination. Crates can be sanitized using the procedure outlined below:

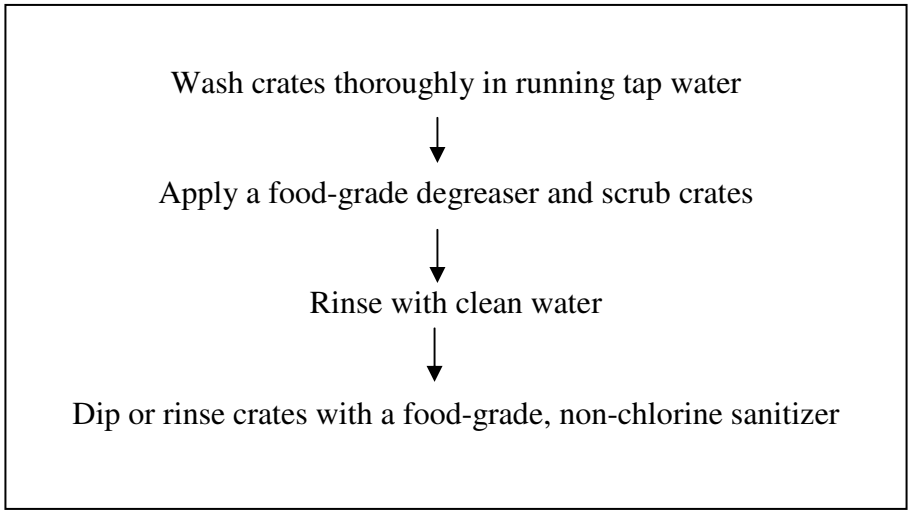

Figure 9: Procedure for sanitizing harvesting crates

Figure 10: Washing harvesting crates

9.3 Vehicle Sanitation

It is quite common in Caribbean agriculture for farm vehicles to be used for a range of different tasks some of which may compromise the safety of farm produce. Farm vehicles that are used for transporting farm produce should not be used for transporting animal manure and as temporary storage for facilitating pesticide operations. These farm inputs can lead to contamination of fruits when the vehicles are used to transport fresh produce to the packinghouse.

Vehicles used to transport fresh produce must at all times be properly washed and the trays sanitised.

Trays can be sanitized using the following simple procedure:

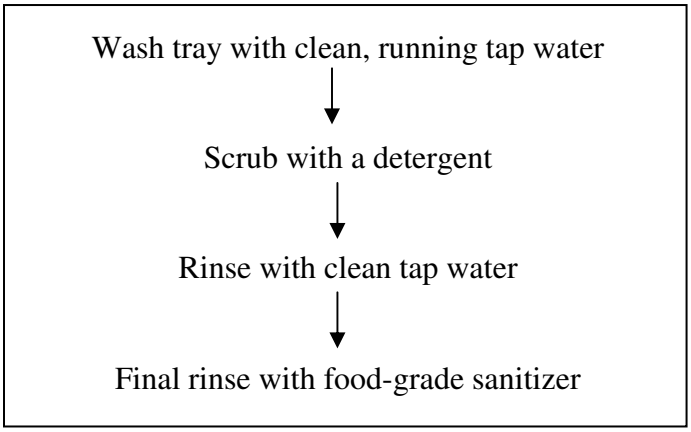

Figure 11: Vehicle sanitation

9.4 Local Packinghouse Operations for Export

Most local exporters use very rudimentary procedures for cleaning, sanitising and packaging shado beni for destination markets. These facilities pay very little attention to packinghouse sanitation, worker hygiene, product handling, pre-cooling facilities and packinghouse infrastructure.

On arrival, the leaves are removed from the transport vehicles. The leaves are normally tied in bundles. They are untied, sorted and washed with water in batches. Because running water is not normally used, the microbial population builds up in the wash water, thereby increasing the risk of spoilage and contamination with food borne pathogens. The leaves are air dried by spreading on wooden tables. They are packaged in perforated low density polyethylene bags, one pound (1lb) per bag. These smaller bags are transferred to a larger, high density polyethylene bag containing between 8-15 lbs per bag. The common complaint from importers is the level of losses due to breakage of the leaves in-transit using this system.

9.5 Improved Packinghouse Operations (For Export)

In order to maintain the quality of the leaves, packinghouse operations must be done quickly and the leaves refrigerated to be precooled within 1-2 hours upon arrival at the packinghouse. If the

workload in the packing facility is high, it is better to store the leaves covered with a damp, clean cloth refrigerated at 12°C and work the order in batches. Leaving the leaves unrefrigerated will result in significant quality loss during marketing.

The leaves should be first sorted. Those clusters which do not meet the particular market requirement should be culled. Selected leaves should be rinsed in running tap water. A common practice among small scale exporters is to dip consecutive batches of leaves in the same container of water. This practice must be avoided at all costs since it encourages accumulation of spoilage microorganisms as well as microorganisms responsible for food borne illnesses.

The leaves are then dipped in a chlorine solution at 100 parts per million chlorine at a pH of 7-7.5. They are then air dried, packaged and stored under refrigeration at 10-12°C. Packaging varies depending on the intended market.

Types of packaging Material:

1. Some exporters use fibreboard boxes lined with low density polyethylene plastic. Leaves are loose packed 8-10 lbs per box.
2. Some markets prefer the leaves be packaged in low density perforated polyethylene bags at a weight of 1 lb per bag. These smaller bags are then placed in lined fibre board boxes and then precooled.
3. Other exporters loose pack the product in high density polyethylene bags 15 lbs per bag. This method has the potential to cause tremendous breakage of the leaves during handling.

9.6 Pest Control

It is critical that pests of public health importance be prevented from entering packinghouse facilities. These pests include cockroaches, rats and birds. Birds must be prevented from nesting on the roofs of packinghouses and in receival bay areas. Their droppings carry very high bacterial populations including *E. coli* 0157:H7 and *Salmonella*.

Rats carry the *Leptospirosis* bacteria in their urine and can easily contaminate produce. Workers are also at risk since any contact with rat urine can result in this debilitating and sometimes fatal disease. Rats are generally nocturnal feeders and it may be difficult to detect them. All measures must be put in place to prevent them from getting into the packinghouse. Some of the measures include:

- Placement of bait stations on the perimeter fence of the packinghouse
- Strategically placing bait stations around the packinghouse
- Securing and removing all garbage on a timely basis and sanitising all bins.
- Keep leaves secured above ground and covered
- Provide baffles at the base of the shelves to prevent them climbing onto the leaves

9.7 Local Marketing

A number of different systems are employed in local retailing of the leaves. Poor harvesting indices, poor transportation and poor storage often result in quality losses during the marketing chain.

Shado beni leaves are harvested, tied in bundles and placed in used fibreboard boxes. They are sometimes transported to wholesale markets in dirty transport vehicles which are overloaded resulting in physical damage to the leaves. Dirty vehicles and dirty field containers increase the risk of microbial contamination. The leaves are offered for sale with no pre-cooling or refrigerated storage. On arrival at the retail outlet, the leaves are sprinkled with water in an attempt to precool. The leaves are often covered with used potato sacks which also raise issues relating to food safety. The quality of the water is also at times very questionable. The photographs below show some of the concerns with locally marketed shado beni leaves.

Figure 12: Shado beni displayed on retail stalls in the hot sun. Quality loss occurs is quite rapid.

Figure 13: Shado beni covered with burlap sacks which are sprinkled intermittently with water

Figure 14: Dirty container and water used for sprinkling leaves.

Figure 15: Leaf breakage due to tying of bundles

Some supermarkets, hotels and fast food outlets are demanding that the leaves for local use be handled similar to those for export. In fact, some hotels and fast food outlets have started to demand third party audits before the leaves are taken from the growers.

IMPROVING PACKINGHOUSE OPERATIONS

The shelf life of the herb can be greatly improved if due care is paid to postharvest handling operations. The series of photographs shows the procedure developed for shado beni at The packinghouse operated by the national agricultural marketing development corporation (NAMDEVCO).

Figure 16: Trimming of shado beni leaves

Figure 17: Washing and sorting of shado beni leaves.

Figure 18: weighing of sorted leaves.

Figure 18: Sleeving of sorted leaves in polyethylene bags.

Figure 19: Sleeved leaves placed in fibre board boxes.

10.0 LIST OF ACRONYMS

GAP	GOOD AGRICULTURAL PRACTICES
USDA	UNITED STATES DEPARTMENT OF AGRICULTURE
US	UNITED STATES
ISO	INTERNATIONA STANDARDIZATION ORGANIZATION
PRP	PRE REQUISITE PROGRAMME
GMP	GOOD MANUFACTURING PROGRAMME
IPM	INTEGRATED PEST MANAGEMENT
EU	EUROPEAN UNION

11.0 List of Pesticides