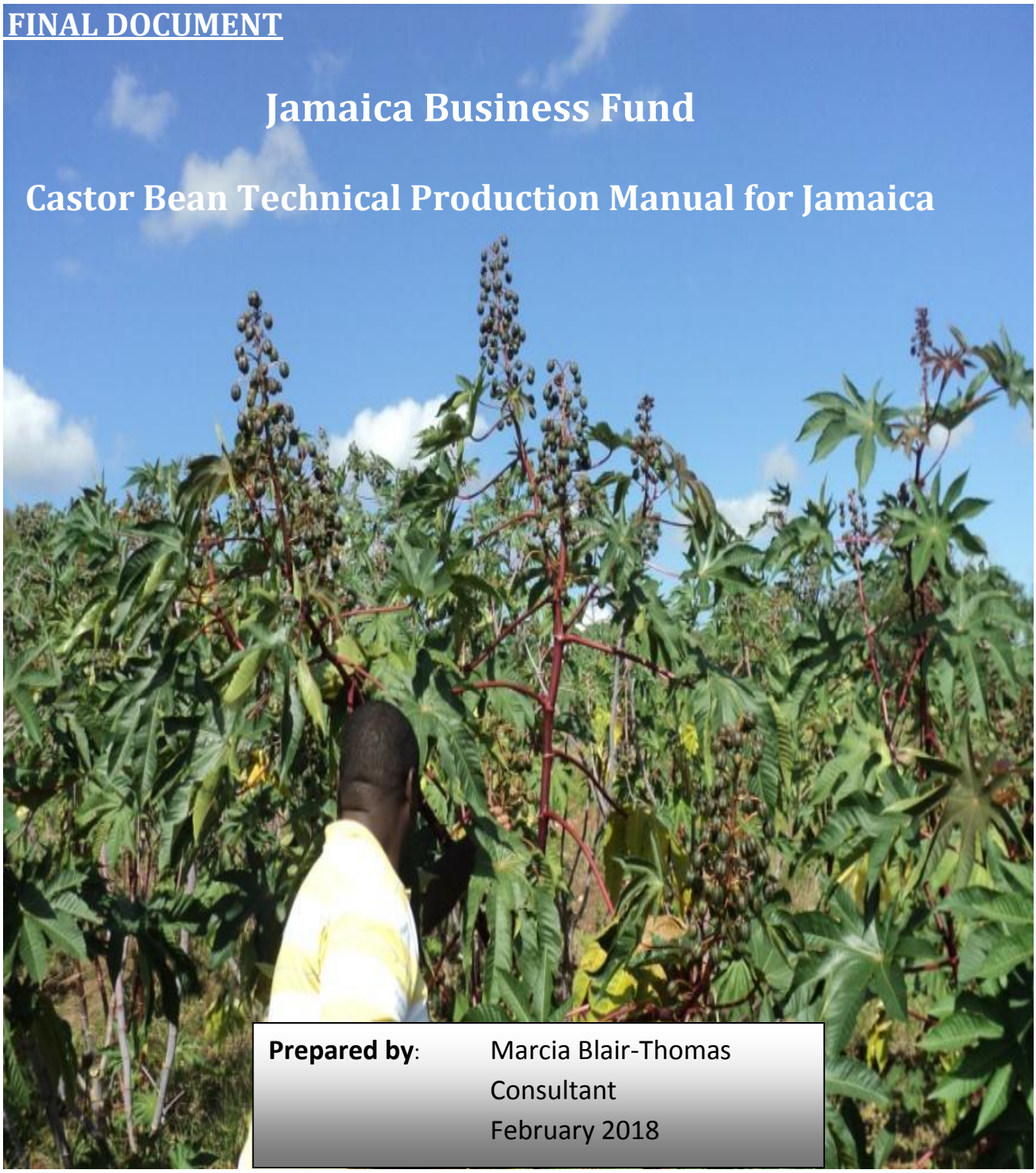
FINAL DOCUMENT

Jamaica Business Fund

Castor Bean Technical Production Manual for Jamaica



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1. Introduction

Castor bean, *Ricinus communis*, is a perennial or annual crop which is grown throughout tropical and sub-tropical regions of the world. It is found growing wild across all parishes of Jamaica and cultivated for oil extraction mainly by small to medium-sized farmers mainly in St. Catherine, Clarendon, Manchester and St. Elizabeth.

The tall, branched shrub produces seeds (8-15mm long, 6-9mm wide and 4-8mm thick) containing 35-55% oil (depending on variety), which may be extracted by a range of/or combination of processes, such as hydrate presses, continuous screw presses and solvent extraction. Yields of as much as 350-650 kg of oil per hectare have been obtained in arid and semi-arid regions, with little crop management.

Although the leaves, stems and seeds of the castor plant have been found to contain the poisonous substances ricin and ricinine, the oil does not contain these poisonous substances, and has been used in a wide range of industrial applications including pharmaceuticals, cosmetics, bioplastics, paints, biofuels etc. Castor bean is one of the most promising non-edible oil crops being investigated as biodiesel feedstocks, due to its high annual seed production and yield, and since it can be grown on marginal land and in semi-arid climates. The castor bean meal may be used as a protein source for swine and an organic fertilizer due to its high nitrogen and phosphorus content, but, cold-pressed oil extracted seed meal is known to contain the ricin cytotoxin. It has been reported however, that the toxic effects may be removed by boiling in calcium hydroxide (pH 12.5) (Barnes et al, 2009). Castor bean may also be used for biomass energy and biochar, which is a valuable soil amendment.

The Jamaican castor bean industry is poised for development and expansion with increasing demand for castor oil on the domestic and international markets. In general, the current rate of castor oil production is not considered sufficient to meet the anticipated increase in demand. Current global castor oil and derivatives market of fourteen (14)

million tonnes is only being met with supplies of approximately 7.5million tonnes. Market value is expected to reach US$1.81billion by 2020 climbing to US$2.33billion by 2024. The annual value of Jamaican Black Castor Oil has been estimated at US$75-100mil.

Given the economic and development potential of the Jamaican castor bean industry, and the relative unavailability of technical information to guide local production in Jamaica, a Castor Bean Production Sector Study, including a ***Literature Review of Studies Conducted on the Production of Castor Bean in Jamaica***, and a ***Castor Bean Technical Production Manual for Jamaica***, was commissioned by the Jamaica Business Fund (JBF) to support and facilitate publication and dissemination of technical information on castor bean production for increased production and productivity. This manual, therefore, aims to provide information on the cultivation, harvesting and post harvest of castor bean to promote adoption of good agricultural practices for improved production and yield.

2. Site Selection and Environmental Requirements

Fig. 1. Site Selection

Although castor bean is highly adaptable and may be grown in most areas of Jamaica, the most favourable environmental conditions for castor bean production include adequate

supply of water in the early stages of growth and average temperatures of between 20-30^{o}C or up to 35^{0}C. The crop is sensitive to high humidity and high temperatures above 40^{o}C negatively impacts crop yield. Approximately 500 to 1,000mm or 20-32 inches of annual rainfall is needed for the first four (4) months of growth after planting. Where rainfall levels fall below 350 mm per annum, irrigation is necessary to achieve good yields. The highest yields are realized on loam to sandy loam soils with very good surface and sub-surface drainage, with adequate subsoil permeability for air and water to facilitate root growth. The land should be relatively flat or with a maximum slope of 12% (approximately 7^{o}), ideally at altitudes of 300m - 1,500m. Castor bean may be cultivated on alkaline or slightly acidic soils ideally within the pH range of 5 - 8 and electrical conductivity (EC) of less than 4.0.

Site selection across the island may be guided by the land suitability assessment which was conducted by the PCJ for castor bean cultivation in Jamaica. Based on suitable texture, pH, soil drainage, slope, rainfall and soil depth parameters, approximately 42,797 hectares of land are deemed suitable/very suitable for castor cultivation in Jamaica, in sections of the top seven (7) parishes of St. Catherine, Clarendon, St. Thomas, St. Elizabeth, Portland, Hanover and Kingston and St. Andrew (Reece, 2017).

3. Land Preparation

Land preparation is ideal for castor bean cultivation in order to effect proper soil aeration and weed control. The crop requires well pulverized, loose sub-soil, approximately 40cm deep, for good seed germination or establishment of seedlings. It is recommended that the land should be ploughed, harrowed and furrowed (bed shaped) prior to planting. If the area is to be irrigated, drip lines and emitters should be placed at the recommended planting distances. Planting should be done on ridges, where the soil is susceptible to water logging. Castor beans should not be planted in an area that is subject to soil erosion.

Fig. 1.Land preparation

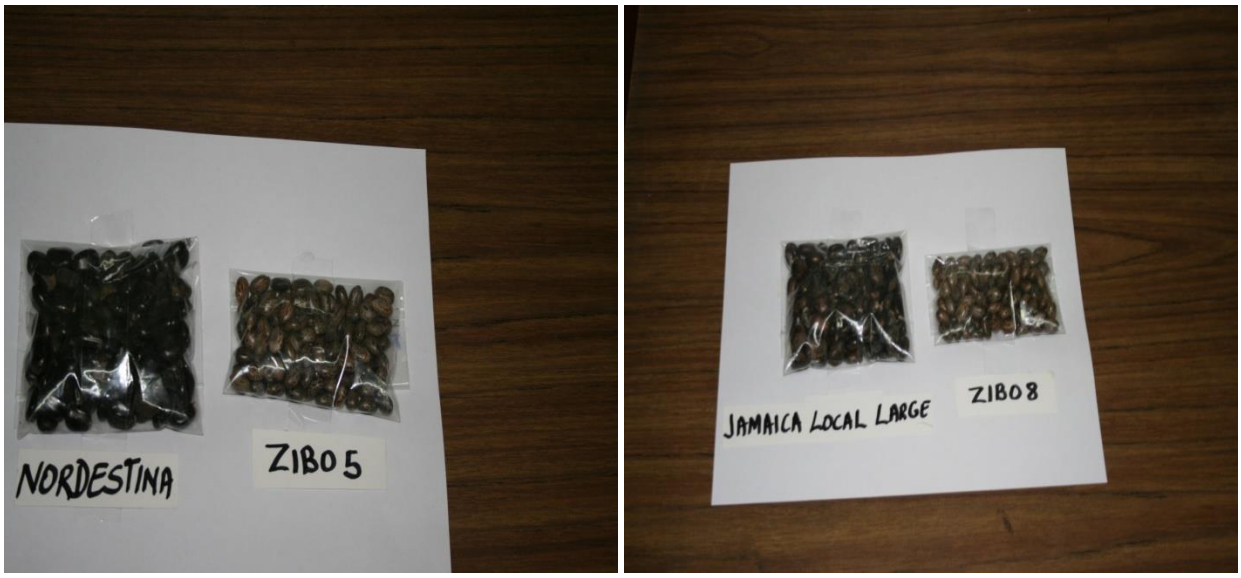
4. Variety Selection

The selection of high yielding, disease resistant and/or tolerant varieties with high germination rates and varieties which are well adapted to the agro-ecological conditions, is one of simplest and cheapest technologies to ensure high productivity. Although over twenty-two (22) genotypes of castor beans have been identified island-wide, there are no true varieties of local castor bean due to cross pollination. Among the varieties which are highly adapted to local conditions with relatively high disease resistance, which may be selected for planting are the local varieties named based on size, including the Jamaica Large, Jamaica Medium and Jamaica Small. Introduced varieties with high oil content and good yields include Nordestina, Zibo, Cimmaron Dwarf , Brazilian Dwarf and Tall, Baker 72, Hale etc. (Please refer to the report *Literature Review of Studies Conducted on Castor Bean Production in Jamaica (JBF 2018*). Based on recent research work conducted in Jamaica, characteristics and yield of six (6) varieties are provided in Table 1 below.

Table 1: Characteristics of six (6) varieties of castor beans produced in Jamaica.

Variety	**Disease Resistance**	**Days to Maturity**	**Yield (kg/ha)**	**% Oil**
Jamaica Large	Most major diseases	155	1345	45.34
Jamaica Medium	Most major diseases	155	1141	45.48
Jamaica Small	Most major diseases	155	1982	43.18
Nordestina	Moderately susceptible	155	1681	45.76
Zibo #5	Susceptible	90	1982	43.71
Zibo #8	Susceptible	90	1982	43.18

-Source: CARDI 2017



-Source: R&D Division, MICAF

Fig 3. Samples of Jamaica Large, Nordestina, Zibo 5 and Zibo 8.

Fig 4. Castor bean plant with mature fruits

5. Crop Establishment

5.1. Seed Selection

Seeds should be cleaned to remove foreign material, seeds with attached hulls, and damaged seeds. They may be treated with fungicide prior to planting to protect them from seed borne diseases such as leaf blight, seedling blight and wilt. In Jamaica, Phyton 27 (active ingredient: copper sulphate pentahydrate) is used.

Fig.5. Cleaned castor bean seeds

Moisture content of seeds should be about 7%, and seeds should not be older than 6 months. Ideally, germination tests should be conducted to ensure seed viability. The acceptable germination rate is approximately 72% and above.

Castor bean seeds may be sown in seedling trays or grow bags containing potting mix and then transplanted or direct seeding may be done.

Fig 6. Seedling trays

5.2. Planting

Transplanting under proper irrigation, preferably utilizing drip irrigation systems, is the more efficient method of propagation. Due consideration should also be given to the provision of adequate water supply with direct seeding and as such, seeds should be sown to coincide with the rainy season. However, regular re-sowing may have to be done with smaller seeds which may be suppressed by eroded soil during heavy rainfall.

In direct seeding, it is recommended that that 2-3 seeds be planted per hole (approximately 6 inches deep), with thinning out of plants from each hole, as necessary, between 10 to 20 days after sprouts emerge. A spacing of 3 m between rows and 2 m between plants may be applied. This will give a plant population of approximately 675 plants to the acre (ac) or 1665 plants to the hectare (ha). Seedlings normally emerge 10 to 21 days after sowing and mature within 90-160 days, depending on variety.

Fig. 7. Established castor bean field

6. Irrigation

Fig. 8. Prepared field with drip irrigation

Higher productivity is usually achieved with good availability of water and as such surface irrigation such as manual or drip irrigation should be implemented. Commercial varieties of castor bean generally require 20.6 to 24.7cm/ha of water annually to produce high

yields. Generally, high temperatures or high winds during the peak growing and fruiting periods may necessitate more frequent irrigation.

Under an optimized irrigation level, a seed yield of 3780 kg ha–1 was obtained in India with the hybrid GCH-5. Seed yields of rain-fed castor fields can be increased by small amounts of supplementary irrigation. The seed yield of BRS Nordestina increased from 873 to 1301 kg ha–1 with early planting and irrigation of 130 mm before the regular rainy season.

7. Crop Nutrition and Fertilization

Soil analysis should always be done to inform nutrition management and fertilization. The most important factor in fertility management of castor beans is the supply of nitrogen in the soil. Insufficient nitrogen results in reduced castor bean yields, while excessive nitrogen produces heavy vegetative growth with little or no increase in seed yield.

The amount of nitrogen required by castor beans depends on the soil organic matter content.

Some recommended nitrogen application rates for castor based on organic matter content are outlined in Table 2. below:

Table 2. Nitrogen application rates based on organic matter content

Soil Organic Matter (%)	Nitrogen Application Rate (kg/ha)
<2	112.1
2 - 4.9	89.7
5 - 10	67.3
>10	44.8

If the soil is deficient in nitrogen, 90 to 135 kg/ha of nitrogen usually are needed for maximum yields. A split application of nitrogen is often used, with the second half applied approximately 1 month after planting.

A minimum of 37 to 56 kg/ha of phosporus is needed for production of castor, and 15 to 19 kg/ha of potassium. If phosphorus is needed, application should be made before planting time. Potassium may be applied at planting time. Castor beans do not generally respond to phosphorus, and excess soil phosphorus levels can actually decrease yields.

A general fertilization technique is the addition of manure to plant holes before seeds are sown. This assists new root formation, promotes better anchorage and retains moisture, which is especially beneficial to the plant during the dry season. Waste castor bean husks and cake may also be reused as an organic fertilizer. Biochar from castor meal may also be incorporated as a soil amendment for improved soil quality and slow release fertilizer.

8. Pests and Diseases and their Control

Fungal and bacterial diseases have been known to be of economic importance to castor bean production in Jamaica. These include gray mould, seedling blight, Alternaria blight, bacterial leaf spot, powdery mildew and Cercospora leaf spot.

8.1. Gray Mould

Gray mould is the main disease of the castor bean plant in Jamaica. It is caused by the *Botrytis ricini* fungus, which penetrates fruits in the flowering phase and manifest in favourable environmental conditions, typically, high relative humidity. Symptoms of the disease manifest on leaves, stems, flowers and capsules and usually begin with blue-toned stains on the inflorescence and branches, which eventually result in the rotting of fruits, branches and other part of the plant. Infection at flowering results in flower rot and affects seed filling. Infected capsules are typically covered by the characteristic grey or ash coloured growth of the fungus and eventually rot and shed off. Symptoms on leaves manifest as circular spots at the early stage of infection, which eventually progress to irregular, light brown legions covered by the gray colour growth of the pathogen. Irregular legions may assume an elliptical or circular pattern and may coalesce and result in foliar blight. Necrotic, sunken legions on petioles and stems may cause strangulation and consequently death of parts above the infected point.

As the pathogen may be dispersed by the wind, disease spread and destructive potential is great. Cultural practices must be applied to prevent introduction of the inoculums into the field and plant spacing may be adjusted to enhance aeration. Regular field inspection is also recommended. With disease establishment, a rotation of fungicide applications, based on the severity of the infestation, and after removal and burning of the infected parts of the plants, may be applied. However, there are currently no pesticides registered for use on castor bean in Jamaica. The following recommendations are therefore based on fungicides registered for use on other crops by the Pesticide Control Authority (PCA). Preventative

sprays may be done at 50% of flowering using dithiocarbomates (Antracol 70 WP ®/Sancozeb®/Dithane M-45®/ Acrobat®/Impetu®). At appearnce of disease symptoms, the second may be done with systemic fungicide carbendazim (Carbendiazim 50 SC®/Rodazim 50 SC®, fludioxonil (Medallion WDG®) or tebuconazole (Xstrata Gold 24 SC®).

Organic control may be effected with application of neem oil or solutions of moringa leaves, guinea hen weed or aloe vera.

Fig. 9. Symptoms of gray mold attack on castor inflorescence (Stock Photo)

8.2. Seedling Blight, Alternaria Blight and Bacterial Leaf Spot

Sowing of the crop in low-lying and water-logged areas should be avoided to prevent the incidence of seedling blight and Alternaria blight. During periods of heavy rainfall and high humidity, capsule moulds, Alternaria leaf spot and bacterial leaf spot may occur. Infected

plant materials should be removed and destroyed and seeds may be pre-treated with Phyton 27 for control.

Seedling Blight is caused by the fungus, *Phytophthora parasitica*, which causes damping-off of seedlings and leaf blight of the castor bean plant. The pathogen is soil-borne and spreads rapidly after heavy rains in low lying and ill-drained soils. Symptoms include dull, green patches on both surfaces of the cotyledon leaves which later spread and causes rotting. The infection moves to the stems and causes withering and death of seedlings. In mature plants, the infection initially appears on the young leaves and spreads to petioles and stems causing black discoloration and severe defoliation.

Management of the disease include removal and destruction of infected plant materials and avoidance of low-lying and ill-drained fields. Crops such as potato and tomato should be avoided in crop rotation as the fungus survives on these hosts. At the early stages of the disease, seedlings may be drenched with the systemic fungicide fosetyl Al (Alette WDG®) at the recommended dose rate or foliar application of a fungicide containing dimethomorph and pyroclastrobin (Cabro Team 18.7 WG), or flupicolide and propineb (Trivia 72.7 WP®).

Fig. 10. Seedling Blight affecting castor bean (Stock Photo)

Alternaria Blight or leaf spot, caused by the fungus, *Alternaria ricini*, affects the aerial parts of the plant (stem, leaves, inflorescence and even capsules). Spots may appear on any portion of the leaf and are irregular and scattered with concentric rings and yellow halo.

The inflorescence is attacked at any age and eventually develops a sooty appearance. A gray-green spore mass may sometimes be seen. In severe attacks, premature defoliation and gradual wilting occurs. Affected capsules are small, under-developed and wrinkled with little oil content. Seed treatment is useful in combating the initial phase of the disease. Alternaria leaf spot is more severe in nitrogen-starved plants. The fungus is externally and internally seed-borne and causes primary infection. The secondary infection is air-borne.

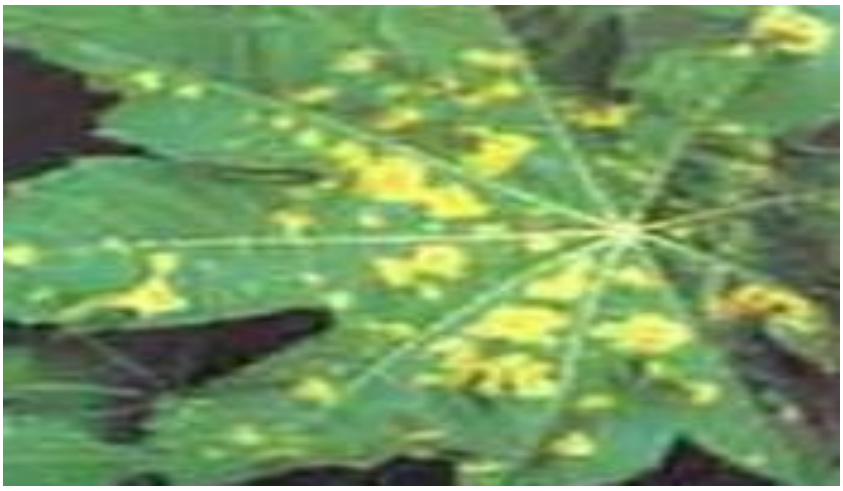


Fig 11. Alternaria Blight affecting castor bean (Stock Photo)

Seed treatment with fungicides is not always effective, as the fungus the fungus presents internally and externally. Preventative foliar spraying with contact fungicides in rotation with curative applications of *pyraclostrobin & boscalid* (Bellis®), *carbendazim* (Carbendiazim 50 SC®/ Rodazim 50 SC®) and *thiophanete-methyl* (Topsoon M 70% WP®) are recommended.

Bacterial Leaf Spot is caused by the bacterium, *Xanthomonas ricinicola,* typically in humid conditions and results in *n*umerous, irregular, small, brown water-soaked spots on leaves, followed by premature defoliation. Spots gradually turn black with dried sections of leaf tissue disintegrating and falling from leaves. Flower clusters are attacked under humid conditions and occasionally, petioles and succulent branches may have minute, oval or linear spots.

Fig. 12. Bacterial Leaf Spot affecting castor bean (Stock Photo)

The disease is seed-borne and is probably transmitted in the wind and rain, with rapid spread in wet weather. Management of disease requires use of clean seeds, good field sanitation, and preventative applications of copper based fungicides. Once the disease is established, there is no effective fungicides/bactericides with curative action. Hot water treatment of seed at 58˚C to 60˚C for ten minutes has been reported as well as growing tolerant varieties. Spraying with copper oxychloride (2kg/ha) or Streptocycline (100g/ha) has also been reported.

8.3. Cercospora Leaf Spot (*Cercospora ricinella*)

This fungal disease appears as minute brown specks surrounded by a pale green halo. The spots enlarge to a greyish-white centre portion with deep brown margin and when several spots coalesce, large brown patches appear but are restricted by the veins. Infected tissues often drop off leaving shot-hole symptoms. In severe infections, the older leaves may be blighted and withered. The fungus survives in soil debris which is the cause of primary infection. Secondary infection occurs by fungal spores through rain splash or wind.

Fig 13. Cercospora leaf spot

Spraying with copper based fungicides (Phyton 27®, Kocide 2000®, Sulcox-OH 50®,ChampDP 37.5 WG®) at early stages of disease is recommended. Application of systemic fungicides *pyraclostrobin&boscalid* (Bellis®), *carbendazim*(Carbendiazim 50 SC® / Rodazim 50 SC®), *thiophanete-methyl*(Topsin M 70% WP) are recommended in rotation with contact fungicides under highly favorable conditions for disease development. The use of resistant or tolerant varieties is the most effective method of combating the disease.

8.4. Powdery Mildew (*Leveillula taurica*)

Powdery mildew is known to affect castor bean plants. It is caused by the fungal pathogen, *Leveillula taurica,* and symptoms are characterized by typical mildew growth which is generally confined to the under-surface of the leaf. When the infection is severe the upper-surface is also covered by the whitish growth of the fungus. Light green patches, corresponding to the diseased areas on the under surface, are visible on the upper side especially when the leaves are held against light. The pathogen survives as oospores on the affected plant tissues and on weed hosts. Cool and wet weather favors disease development.

Foliar application of sulfur, copper-based fungicides or systemic fungicides such as *pyraclostrobin & boscalid* (Bellis®), *azoxystrobin* (Amistar 50WG ®) and *thiophanate-methyl*

(TopsinM 70% WP®) are recommended.

8.5. Insect Pests, Mites and Snails

Though leaf and stem-feeding insects usually do not cause serious damage to castor bean plants, cutworms and wire worms may reduce stands. Stink bugs and several species of caterpillar (corn earworms, webworms, armyworms), white flies, thrips, and leaf miners may attack the plants. Several natural enemies such as lady bugs, spiders, lace wings, parasitoid wasps and mites usually prey on these pests and their preservation is important for keeping pest populations in check. Use of 'softer', low-toxicity insecticides may be done as necessary, based on regular field inspections. Using a rotation of different chemical groups is also important to prevent resistance to pesticides.

Recommendations for the control of chewing insect pests such as caterpillars include *Bacillus thuringiensis* (Agree® / Xentary®/ Dipel®), *azadirachtin* (Bioneem® / Neem-X®), *lufenuron* (March®) and i*ndoxacarb* (Firststriker®/Indicarb®). Applications of *azadirachtin (*Bioneem / Neem-X), Diazinion or Malathion or Carbaryl.

Red spider mites may be controlled with Caratrax, while the use of slug baits at the recommended rates effect good control of snails. Organic control of snails include the application of powdered seeds and leaves of tobacco.

Fig. 14. Red spider mites

Fig. 15. Snail feeding on leaves (Stock Photo)

9. Weed Management

Weed control is of paramount importance in castor bean cultivation because of its slow emergence (10-21 days) and early growth. The critical period for weed competition is the first 20 to 60 days after seeding. Application of a pre-emergence herbicide will provide early weed control and other strategies may be applied over the life of the crop for management of weeds. This include rotary hoeing during the first few weeks after planting, mulching with guinea grass or other plant/inorganic material, especially in dry areas, which also reduces erosion, retains moisture, and keeps the roots of the plants cool. Intercropping castor plants with leguminous plants is also recommended for weed control and ground cover protection. However, to avoid shading, planting should be done at least 15 days after the castor beans and adequate spacing should be maintained from the line of castor beans. Leguminous plants with creeping characteristics should be avoided. Other crops such as pumpkin, potato, melon, cantaloupe and cucumber are also suitable for intercropping after the first 3 months.

In irrigated castor bean, 2 to 3 hand weddings at an interval of 15 days, starting 15 days after seeding can check weed growth effectively. In rain fed castor crop, two or three inter-cultivations with blade harrows along with a manual weeding within the rows is recommended, starting from 20 days after seeding. Mechanical weed control in the immediate vicinity of plants should be avoided because the main lateral roots of the castor bean plant are near the soil surface. Alternatively, the following herbicides may be applied to effectively control the weeds: *metolachlor* (Dual Gold 960 EC®/Metachlor 960 EC®), *pendimethalin* (Pendigan 33 EC®/ Pendigan 33 EC®/ PROWL 45.5 CS®), *glyphosate* (Glyphosate 41% SL®/ Roundup Ultra®/ Credit Extra®/ Redit41 EXTRA®/ Touchdown IQ®).

The use of ruminants (goats) to graze weeds in castor plantations is not recommended as debarking of the plants has been observed in local experiments.

Fig. 16. Castor bean plants damaged by goats (Source: R&D Division, MICAF)

Note: 1. *Only pesticides registered in Jamaica by the pesticide Control Authority (PCA) should be used. All pesticide products should be applied strictly in accordance with label recommended dose rates and volume rates. Spray equipment should calibrated and applications done during early of morning or in the afternoon.*

2. Information on pesticide registration can be obtained from PCA website: www. caribpesticides.net

3. *Maximum Residue Limits (MRS) established for castor bean can be checked using the following websites. Search can be also done using castor bean's sub-group:20B / sunflower.*

4. EU Pesticides database*: http://ec.europa.eu/food/plant/pesticides/eu-pesticides-database/public/?event=homepage&langua*

5. Global MRL database*: https://www.globalmrl.com/db#pesticides/query*[1]

[1]*The author wishes to acknowledge contributions to the Pests/Diseases/Weed Management section by Mrs. Marina Young, Technical Services Department, RADA.*

10. Harvesting

In order to prevent premature seed dispersal, local varieties should be harvested when the coat covering the capsules is removable and the colour of capsules changes from green to yellowish-brown and a few capsules start drying. Generally, 15-30% of the bunches (panicles) should be dried. Castor produces 4-5 sequential order bunches which may be conveniently harvested in 3-4 pickings, starting from 90-120 days, at intervals of 25-30 days. Premature harvesting leads to reduced seed weight, oil content and germination. Bunches may be harvested by hand, pruning scissors or pole pruners for taller branches.

Fig. 17. A castor bean bunch or panicle with a few dried capsules

Harvested bunches may be placed in bags or boxes and transported to the drying area. After harvest, stalks should be broken up mechanically and worked into the soil to furnish organic matter. Castor bean hulls may also be used as organic matter. Seeds remaining in the field may result in a volunteer problem in the next year's crop. Ploughing in the young plants after the seeds germinate and crop rotation with a row of grain crop will assist in control.

11. Drying and Storage

To prevent loss of seeds when capsules erupt, harvested castor beans should be placed in a drying house or on a barbeque/drying mat and covered with mesh. Bunches should be spread out and turned several times for several days. Seeds may then be separated from capsules either manually or mechanically, stored in pods or shelled and placed in aerated bags. Seeds should be stored in a dry cool place, at room temperature and at less than 6% moisture. Seeds should not be stored in the open, as both heat and sunlight will negatively affect germination and oil content. Foreign material, and cracked or broken seeds are considered in grading the seed.

Fig 18. Harvested cleaned castor beans (Zibo 5)

12. Mitigation of Climate Events and Risks Associated with Production

Mitigation of climate events and associated risks are critical considerations for successful production of castor bean. These include:

- Selection of drought tolerant and disease resistant varieties;
- Mechanical drying.
- Intercropping with leguminous and runner crops to prevent soil erosion;
- Use of drip irrigation systems;
- Use of mulching for moisture conservation;
- Drainage;
- Mechanical harvesting;

13. Policy, Institutional and Operational Constraints and Priority Areas for Attention in the Jamaican Castor Industry

No specific policy currently exists for the targeted development and expansion of the Jamaican castor bean industry, however, broad-based policies relevant to agriculture, export, manufacturing and protection, which are implemented across various portfolio ministries of government, offer support to its growth and development. These include the National Export Strategy, the Agricultural Incentives, Manufacturing and Biofuels policies as well as geographic indicators/location-linked regulations.

The main policy, institutional and operational constraints which require priority attention in the Jamaican castor bean industry include:

- weak coordination;
- poor industry oversight, regulation and communication channels;
- weak internal market linkages;
- lack of product quality control and quality testing instruments;
- insufficient access to capital and investment;
- information asymmetry between overseas distributors and Jamaican producers;
- inadequate supply of raw material for value-addition;

- inadequate use of improved technologies;
- lack of mechanization.

The generally weak industrial and market coordination and cooperation between castor bean sector actors is being addressed since the formation and formal registration of the Jamaica Castor Industry Association (JCIA) in January 2017, which has been facilitated through the Jamaica Promotions Corporation (JAMPRO). This is a part of the Corporation's long-term strategy to development the castor bean industry for exports and investments through capacity building initiatives, business matchmaking opportunities, trade missions etc. JAMPRO has also partnered with the JCIA to create more business opportunities for castor raw material producers and value-added manufacturing enterprises and will provide market intelligence to target export sales contracts, identify distributors for the products, and facilitate business matching and lead generation.

Linkages with the Ministry of Industry, Commerce, Agriculture and Fisheries need to be strengthened to facilitate policy imperatives and support for research on genetic improvement, value-added production, agronomic best practices, pest management, improved harvesting and post-harvest techniques, training, extension support, standards and quality management systems, intellectual property protection, and incentives. However, JAMPRO has started to facilitate acquisition of intellectual property rights (geographical indicators and trademarks) through the Jamaica Intellectual Property Office (JIPO), which is critical to protecting the Jamaican Black Castor Oil (JBCO) brand. The JCIA has also partnered with JIPO to register geographical indicators for JBCO and trademark the Jamaican brand in the US, one of the major target markets for the oil. Steps have also been taken towards addressing weaknesses in quality management systems through the Bureau of Standards Jamaica and the Scientific Research Council, which has partnered with the JCIA and JAMPRO, for the testing of castor oil from local oil producers with the aim of establishing a recognized standard for the JBCO.

It is also recommended that steps be taken towards signing and ratification of the *Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from the Utilization of Genetic Resources of the Convention on Biological Diversity*

(Nagoya Protocol), through the Ministry with responsibility for Environment. This is especially important in addressing traditional knowledge in respect of local castor bean varieties and the sustainable production of authentic JBCO.

Improvement of funding and incentives mechanisms requires urgent priority attention to address these critical priority constraints including prevalence of traditional processing technologies and a lack of mechanization (for larger tracts of land). It has been noted, for example, that mechanization increases the amount of oil obtained from the beans from 19.42 per cent to 38.84 per cent.

14. Brief Investment Profile for Castor Bean Production

Castor bean is widely grown throughout the sub-tropical and tropical regions of the world chiefly for the versatile oil produced from its seed. Castor oil has a wide range of industrial applications including biodiesel, lubricants, pharmaceuticals, cosmetics, textile, paints, varnishes etc. Castor bean meal has also found application as a protein source for swine and use as an organic fertilizer.

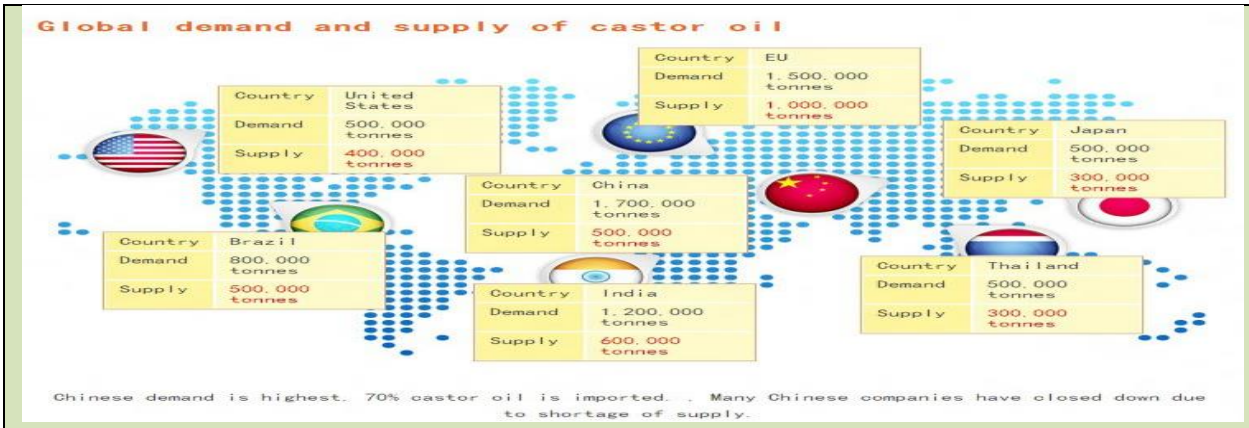
The crop is highly adaptable to Jamaica's agro-ecological conditions and may be cultivated across all parishes. Commercial cultivation mainly for oil extraction is currently being done by small and medium-sized farmers mainly in St. Catherine, Manchester, Clarendon and St. Elizabeth.

The most suitable agro-ecological conditions for growing castor bean include:

- Adequate supply of water in the early stages of growth. Approximately 20-32 inches or 500 to 1,000mm of annual rainfall is recommended for the first four (4) months of growth after planting.;
- Average temperatures of between 20-35^{0}C.
- Loam to sandy loam soils with very good surface and sub-surface drainage;
- Relatively flat or with a maximum slope of 12% (~7^o) ideally at altitudes of 300-1,500m;
- Alkaline or slightly acidic soils ideally within the pH range of 5-8
- The crop is sensitive to high humidity.

Market Demand and Value

Castor bean is cultivated commercially in over thirty (30) different countries with India, China, Brazil, Russia, Thailand, Ethiopia and Philippines accounting for approximately 88% of world seed production. India, the largest producer of castor seed and castor oil in the world, contributes approximately 55-60% of world production. The main importers of castor oil are China, European Union and the USA.



*Source: www.castoroilworld.com/statistics-market-demand-future-trend/

The Jamaican castor bean industry is strategically positioned for tremendous development and expansion with increasing demand for castor oil on the domestic and international markets. Currently, only approximately 50% of the global demand for castor oil and its related products is being met. The global market for castor oil and its derivatives is currently 14 million tonnes, but supplies are at just 7.5 million tonnes. It is expected to reach US$1.81bil by 2020 and US$2.33bil by 2024, driven by key end-use industries including pharmaceuticals, biodiesel, lubricants, bio-plastics and cosmetics.

The strength of the Jamaican castor industry is based on the competitive advantage of Jamaican Black Castor Oil (JBCO), which has a strong brand and quality reputation in North America and Europe, particularly in the hair and skin care industries. The estimated annual value of retail sales of JBCO and its related products worldwide is between US$75-100mil and the price per gallon is 5 - 10 times the price of commercial grade castor oil at USD $12 - 15 and USD $3 - 8, respectively. Authentic JBCO produced in Jamaica averages twice the price of JBCO produced across the world.

Local demand for castor is skewed to the personal care industries, with an emerging possibility for fuel (biodiesel) production. In general, the local demand remains relatively small, but growing, and export potential is large. Downstream activities in castor oil extraction technologies will create further value to the industry**.**

Production Costs

Cost of Production estimates for the cultivation of 1 acre of the Nordestina castor bean in Jamaica was estimated at J$145.15/kg (Bodles Research Station) (see Appendix 1 below). This is based on total production costs of J$131,952 including labour operations, material inputs and transport and packaging, and a projected marketable yield of 909 kg per acre. Assumptions include land availability (land lease costs, estimated at J$10,000/acre) are not included.

Return on Investment

Based on expected yields of approx. 2,000lbs of seeds per acre, and sales price of J$150/lb,

an investment of $212,000 per acre (including investment of $80,000 for capital costs (irrigation) and production costs of $132,000) is expected to generate total revenue and profit of $300,000 and $88,000 per acre, respectively, giving an estimated return on investment of 41.5%. It is expected that, as the industry grows, likely from new entrants and expansion, return on investment in primary production of castor beans should moderate.

Projected returns on investment for investment sizes up to 15 acres are presented below:

Investment Size /acres	Capital Cost /J$	Production Cost/J$	Revenue /J$	Profit/J$	Return on Investment
1	80,000	132,000	300,000	88,000	41.5%
5	400,000	660,000	1,500,000	431,000	
10	800,000	1,320,000	3,000,000	880,000	
15	1,200,000	1,980,000	4,500,000	1,320,000	

***Assumptions:** No significant cost saving from economies of scale between 1 and 15 acres;
Land lease costs are not included;
No external shocks;
Market availability

Investment Size

Based on the economics of castor cultivation in Jamaica and the necessity for economies of scale, the recommended minimum economic unit of cultivation is five (5) acres and average farm size of 15 acres. With labour-intensity of harvesting and climate variability, consideration should be given to restricting individual farm size to a maximum of 100 acres unless mechanical harvesting is available.

Key Risks Associated with Cultivation

Key associated risks which are critical considerations in castor bean cultivation include:

- Pest and disease outbreaks, particularly mold and leaf spot disease with high humidity;
- Unfavourable weather conditions, including drought and flood;
- Price instability for seeds and output;
- Constraints (scale, technology, market reach) in down-stream activities.

Support Institutions and Stakeholders

Key support institutions and stakeholders include:

- Producers and producer groups - small farmers and Jamaica Castor Industry Association;
- Value-added manufacturers Jamaica Black Castor Oil
- Input suppliers - planting material, nutrition and pest management companies/organizations;
- Jamaica Promotions Corporation (JAMPRO) - coordination, investment and trade facilitation;
- Ministry of Industry, Commerce, Agriculture and Fisheries and agencies/departments - Rural Agricultural Development Authority (extension and

training); R&D Division (research and development); Bureau of Standards Jamaica (standards and quality); Jamaica Intellectual Property Office (JIPO) (intellectual property protection);

- Ministry of Science, Energy and Mining - Petroleum Corporation of Jamaica (biodiesel); Scientific Research Council (research, standards and quality); Jamaica Bauxite Institute (research);
- Non-governmental organizations and community groups eg. Jamaica Baptist Union;
- Funding organizations and investors

List of Appendices

Appendix 1. Castor Bean Cost of Production (0.4ha.) (Nordestina variety - Bodles Research Station)

ITEM	UNIT	# OF UNITS	COST/UNIT $	TOTAL COST $
LABOUR OPERATIONS				
LAND CLEARING	HRS	4	9000	36,000.00
	MANDAY	1	1500	1,500.00
LAND PREPARATION (Ploughing)	HRS	3	9000	27,000.00
HARROWING	HRS	2	9000	18,000.00
TRENCHING	MANDAY	6	1500	9,000.00
LINING OUT	MANDAY	1	1500	1,500.00
PLANTING	MAN DAY	1	1500	1,500.00
SUB-TOTAL - LABOUR COST				**94,500.00**
MATERIAL INPUTS				
PLANTING MATERIAL	lbs	3	450	1,350.00
SUB-TOTAL MATERIAL INPUT				**1,350.00**
FERTILIZER				
NPK- 12-22-22	50 kg	1	4200	4,200.00
INSECTICIDE				
KARATE	litre	0.25	2050	512.50
PLANTGUARD	kg	1.25	1200	1,500.00
FUNGICIDE				
STICKER	litre	0.25	1050	262.50
SUB-TOTAL MATERIAL (OTHER)				**6,475.00**
OTHER CHARGES				
TRANSPORT	TRIPS	3	4000	12,000.00
PACKAGING MATERIAL		25	60	1,500.00
SUPERVISION,AUDIT,LABOUR				5,894.00
CONTINGENCIES	10% OF LABOUR AND MATERIAL			10,232.50
SUB-TOTAL OTHER				**29,626.50**
GRAND TOTAL				**131,951.50**

Crop	-	Castor Bean	Terrain	-	Relatively Flat Land Farm
Variety	-	Nordestina	Land Preparation	-	Mechanical
Crop Maturity	-	6 months	Irrigated/Rain fed	-	Irrigated
Reaping Period	-	18 months	Area (hectare)	-	0.4
Planting Distance	-	300x300cm (120x120in)	Projected Marketable)-		909
Planting Density @0.4ha-		436	Yield (kg		
		Cost of Production $/kg		**$145.15**	

Appendix 2. List of Abbreviations

BSJ.....Bureau of Standards Jamaica

CARDI.....Caribbean Agricultural Research and Development Institute

JAMPRO.....Jamaica Promotion Corporation

JBCO.....Jamaica Black Castor Oil

JBI.....Jamaica Bauxite Institute

JBF.....Jamaica Business Fund

JBU.....Jamaica Baptist Union

JCIA.....Jamaica Castor Industry Association

JIPO .....Jamaica Intellectual Property Office

MICAF.....Ministry of Industry, Commerce, Agriculture and Fisheries

PCA.....Pesticide Control Authority

PCJ.....Petroleum Corporation of Jamaica

RADA.....Rural Agricultural Development Authority

SRC.....Scientific Research Council

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Appendix 4. List of Consultations

Institution	**Contact**
Ministry of Industry, Commerce, Agriculture and Fisheries, Research and Development Division	Mrs. Carla Douglas
Ministry of Industry, Commerce, Agriculture and Fisheries, Economic Planning	Mr. Rohan DaCosta Mr. Carlton Wedderburn
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Jamaica Baptist Union	Dr. Judith Johnston
Jamaica Castor Industry Association	Mr. Joel Harris Mr. Basil Hylton Ms. Shirley Lindo
Rural Agricultural Development Authority	Mrs. Marina Young