

CASTOR BEAN (RICINUS COMMUNIS)

AN INTERNATIONAL BOTANICAL ANSWER TO BIODIESEL PRODUCTION & RENEWABLE ENERGY



*Total Renewable, Sustainable Organic Solutions
to the Global Energy, Water & Environment.*



DOVE BIOTECH LTD.
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MOTIVATION FOR THIS STUDY

Castor Bean (*ricinus communis*) has been widely accepted as an agricultural solution for all subtropical and tropical locations that addresses the need for commercial crops with low input costs and at the same time provides traditional farming with a viable income from current non-productive lands:

- Castor Bean does not compete with food crops, as Castor Bean can be grown on marginal lands, which are not competitive with food production lands.
- Castor Bean is not competing with food grade oils.
- Its toxicity is sensed by animals and therefore not foraged on.
- It is high yielding, yielding as much as 350-650 kg of oil per hectare when no maintenance is applied to the crop i.e. fertilizers etc, to a high end yield where annual rainfalls happen at the right times, (1000 liter per hectare).
- It has a very high oil content of approximately 50%.
- The oil seed is collected by hand, by picking the ripe pods from the plant.
- It requires only moderate rainfall (approx. 600mm only) and can withstand long periods of drought, but will thrive under higher rainfall.
- It is an uncomplicated crop that requires little attention during its growing periods.
- Due to its low demand on soil fertility, it is ideal to replant marginal lands to prevent desertification and erosion.

Given the similar geographical, climatic and lack of rural employment opportunities, growing a crop for renewable energy provides the answer for long term prosperity. It is generally accepted that no matter how much oil seed is produced, there will not be an over supply for many decades to come.

DOVE BIOTECH has long appreciated both the economic benefits and ecological benefits of planting Castor Bean (*ricinus communis*) for bioenergy production. Combined with **Dove Biotech's "State of the Art" technologies for Biodiesel and Biogas**, Castor Bean (*ricinus communis*) **there are both short and long term benefits for a truly holistic bioenergy projects in developing and developed countries in the tropical and sub tropical belts of the world.**



Assessment of the impact of the dissemination of “the Castor Bean (*ricinus communis*) System” on the ecology of the rural area and the social and economic situation of the rural population (target group) in arid and semi arid regions.

1. CASTOR BEAN – A FUEL SOURCE FOR THE FUTURE



In the search for more environmentally friendly fuels, the use of castor oil as “Biodiesel” has proven to have technical and ecological benefits, and stands as an opportunity for agricultural development in arid and impoverished areas throughout the tropics and sub tropics globally. **DOVE BIOTECH LIMITED** has completed a series of investigations on the Castor bean, and concluded that for arid and semi arid regions, growing Castor Bean in conjunct with *Jatropha* offers the only viable solutions for turning marginal lands into viable economic lands.



The oil extracted from the castor bean (*ricinus communis*) already has a growing international market, assured by more than 700 uses, ranging from medicines and cosmetics to substituting petroleum in the manufacturing of Biodiesel, plastics and lubricants.

Each hectare of castor oil bean plants planted in arid and semi arid regions produces 350-650 kg of oil, **which in turn produces 350-650 kg of Biodiesel per hectare**. It should be noted that these production figures are without any form of commercialization i.e. fertilizers and any form of irrigation.



1.1 Generating Jobs and Additional Economic Benefits

By establishing local, ongoing demand for castor bean oil, by incorporating **Dove Biotech Bioenergy technologies, such as Biodiesel and biogas**; this demand will provide the impetus for the re-establishment of castor bean farming in arid regions globally. Having castor bean production scaled up to industrial levels in these arid regions globally; to supply the **Dove Biotech Technologies with raw material feedstock** will provide a steady income for approximately **4,500 farming families** for each 18,000 liter per day Biodiesel production facility installed.

1.2 The Dove Biotech Castor Bean Program Also Helps To Reduce Global Warming



An unintended but important advantage to a castor bean project is that the **plants absorb carbon dioxide**, thereby reducing greenhouse gas accumulations in the atmosphere. **The estimated carbon dioxide absorption level of castor bean plants is 34.6 tonnes per hectare, with two growing cycles per year.**

1.3 What Castor Oil can do – Chemical Reactions



Castor oil and its derivative castor Biodiesel is indispensable for preventing fuels and lubricants utilized in aircraft and space rockets from freezing at extremely low temperatures. Raw Castor Oils' major market is beginning to open in the energy field, with the growth of Biodiesel. Biodiesel, chemically known as an ester, is the result of the reaction between any oily acid and ethyl (ethanol) or methyl (methanol) alcohol.

In Europe and the United States, nearly two billion litres of Biodiesel are consumed annually, though their oil sources are primarily rapeseed and soy. Castor oil is the best substance for producing Biodiesel because it is the only one that is soluble in alcohol, and does not require heat and the consequent energy requirement of other vegetable oils in transforming them into fuel.

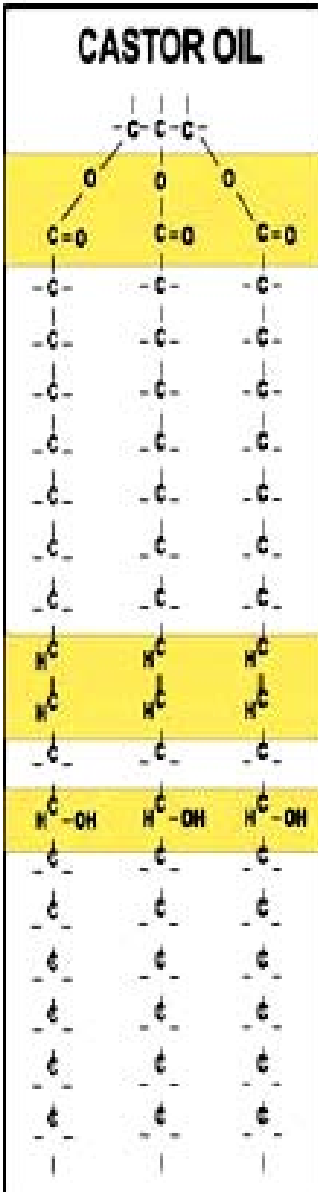


The castor-oil plant is easy to grow and is resistant to drought, which makes it an ideal crop for the extensive semi-arid regions globally. That area globally holds some twenty million hectares of appropriate land that could yield up to 1.5 tons of castor beans per hectare, compared to the global average of 750 kilos per hectare. Castor beans could become a farming alternative, providing income for over one hundred million people who suffer hunger in the poorest regions globally.

Recent studies and genetic improvements have increased the oil content of the castor bean from 24 to 48 percent. In comparison, soy is just 17 percent.

The plant has also been bred to mature at a shorter height. Whereas the castor-oil plant traditionally reaches three meters in height, making mechanized harvest difficult, there are now varieties that grow to just 1.7 meters. These short varieties are mostly commercing grown in Europe.



CASTOR OIL		CHEMICAL REACTIONS OF CASTOR OIL		
 <p>ESTER LINKAGE</p>	(1) Hydrolysis	Acid, enzyme, or Twitchell reagent catalyst	Fatty acids Glycerol	
	(2) Esterification	Monohydric alcohols	Esters	
	(3) Alcoholysis	Glycerol, glycols, pentaerythritol, etc.	Mono and diglycerides, monoglycerols, etc.	
	(4) Saponification	Alkalies alkalies plus metallic salts	Soluble soaps Insoluble soaps	
	(5) Reduction	Na reduction	Alcohols	
	(7) Amidation	Alkyl amines, alkanolamines, etc.	Amine salts Amides	
	(8) Halogenation	SOCl ₂	Fatty acid halogens	
	<p>DOUBLE BOND</p>	(8) Oxidation, polymerization	Heat, oxygen, crosslink agent	Polymerized oils
		(9) Hydrogenation	Hydrogen	Hydroxystearines
		(10) Epoxidation	Hydrogen peroxide	Epoxidized oils
		(11) Halogenation	Cl ₂ , Br ₂ , I ₂	Halogenated castor oil
		(12) Addition reactions	S, maleic acid	Polymerized oils
	<p>HYDROXYL GROUP</p>	(13) Sulfonation	H ₂ SO ₄	Sulfonated oils
(14) Dehydration		Catalyst (plus heat)	Dehydrated castor oil	
(14a) Hydrolysis, distillation			Octadecadienoic acid	
(15) Caustic fusion		NaOH	Seladic acid Capryl alcohol	
(16) Pyrolysis		High heat	Undecylenic acid Heptaldehyde	
(17) Halogenation		PCl ₅ , POCl ₃	Halogenated castor oil	
(18) Alkoxylation		Ethylene and/or propylene oxides	Alkoxyated castor oils	
(19) Esterification		Acetic-, phosphoric-, maleic-, phthalic anhydrides	Alkyl and Alkylaryl esters Phosphate esters	
(20) Sulfation		H ₂ SO ₄	Sulfated castor oil (Turkey red oil)	
(21) Urethane reactions		isocyanates	Urethane Polymers	

2. DESCRIPTION OF THE PLANT, DISTRIBUTION, ECOLOGY

2.1 CASTOR BEAN – THE PLANT

2.1.1 History of the Castor Bean

It was known to Herodotus, who calls it *Kiki*, and states that it furnishes oil much used by the Egyptians, in whose ancient tombs seeds of *Ricinus* were found. At the period when Herodotus wrote (the fourth century B.C.), it would appear to have been already introduced into Greece, where it is cultivated to the present day under the same ancient name. The *Kikajon* of the Book of Jonah, rendered by the translators of the English Bible, 'gourd,' is believed to be the same plant. *Kiki* is also mentioned by Strabo as a production of Egypt, the oil from which is used for burning in lamps and for unguents. Theophrastus and Dioscorides, in the first century, describe the plant, Dioscorides giving an account of the process for extracting the oil and saying that it is not fit for food, but is used externally in medicine, and stating that the seeds are extremely purgative. Pliny, about the same time, also speaks of it as a drastic purgative.

We read of it being employed medicinally in Europe during the early Middle Ages: it is recorded that it was cultivated by Albertus Magnus, Bishop of Ratisbon, in the middle of the thirteenth century, but later it fell into disuse, though Gerard (1597) was familiar with it under the name of *Ricinus* or *Kiki*: the oil, he says, is called *Oleum cicinum* and used externally in skin diseases. As a garden plant, it was well known in this country in the time of Turner (1551). In the eighteenth century, its cultivation in Europe as a medicinal plant had, however, practically ceased, and the small supplies of the seeds and oil required for European medicine were obtained from Jamaica. The name 'Castor' was indeed originally applied about this period to the plant in Jamaica, where it seems to have been called 'Agnus Castus,' though it bears no resemblance to the South European plant properly so called. The botanical name is from the Latin *Ricinus* (a dog-tick), from the form and markings of the seed.



This stout, robust shrub-like plant with reddish to purple stems may reach 12 feet in height. The large (4 to 30 inches across), umbrella-like leaves have 5 to 9 pointed, finger-like lobes. Long purple leaf-stems are attached near the centers of the leaf blades. Greenish-white or reddish-brown flowers are produced in narrow, upright clusters. The fruit is a three-lobed, green or red capsule with a soft, spiny exterior. One large, mottled, attractive seed develops in each lobe. The flowers are male and female on the same plant, and are produced on a clustered, oblong, terminal spike.

The male flowers are placed on the under portion of the spike; they have no corolla, only a green calyx, deeply cut into three to five segments, enclosing numerous, much branched, yellow stamens.

The female flowers occupy the upper part of the spike and have likewise no corolla. The three narrow segments of the calyx are, however, of a reddish color, and the ovary in their centre is crowned by deeply-divided, carmine-red threads (styles). The fruit is a blunt, greenish, deeply-grooved capsule less than an inch long, covered with soft, yielding prickles in each of which a seed is developed.

The seeds of the different cultivated varieties differ in size and in external markings but average seeds are of an oval, laterally compressed form. The smaller, annual varieties yield small seeds- the tree forms, large seeds. They have a shining, marble-grey and brown, thick, leathery outer coat, within which is a thin, dark-colored, brittle coat. A large, distinct, leafy embryo lies in the middle of a dense, oily tissue (endosperm).

3.0 CASTOR BEAN AGRONOMY

3.1 Adaptation

Highest yields of castor are produced under irrigation on fine or medium textured soils, and where low relative humidity prevails. Areas where soils are infested with the cotton root-rot fungus should not be considered for growing castor, because the plants are highly susceptible to this disease (Brigham and Spears 1961). At least a 140-day growing season is required to produce satisfactory yields of castor seed, and a 150 to 160-day season is more desirable. In arid and semi arid regions the actual growing season to first harvest may be increased to 170 days.

3.2 Cultural Practices

Seedbed preparation is similar to cotton, maize, sorghum, soybean, and other row crops. Deep tillage, such as chiseling 20 to 30 cm deep, encourages development and deeper penetration of the tap root. Castor is usually planted in a shallow furrow by opening a bed with a lister-type planter, or planting can be on low beds. Beds usually are irrigated before planting by running water down the furrows. Land should be prepared for 0.96 to 1.01 m rows to fit the available harvesters or for using a tractor for harvesting with manual picking. For hand picking the rows can be narrower.

Castor bean should be planted when the soil is warm--a 10 day average of 15.6°C at 20 cm depth. Only seed of high germination and of good quality should be planted to assure timely emergence and adequate plant populations. **Dove Biotech recommends that making use of local or indigenous species will increase not only production levels, but will also avoid potential crops being host to pests, as the local or indigenous varieties have developed locally and are therefore not prone to various diseases and pests.**

Castor seeds are large and slow to germinate; emergence of the seedlings may take 7 to 14 days. Seeds should be planted 6.3 to 7.6 cm deep, depending on texture and condition of the soil. If press wheels are used in contact with the seed, care should be taken that they do not crush the seed. Castor is planted in 0.96 to 1.01 m rows, with a seeding rate of **11.2 to 15.7 kg/ha and plant spacing of 20 to 25 cm within the row**. Special care must be taken to prevent crushing the fragile seed in the planter box. Air planters are ideal, and can space seeds precisely.

Adequate amounts of nitrogen, phosphorus, and potassium must be available to produce high yields of castor seed. Levels of these nutrients should be determined by soil test. 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 side dressed between the rows at last cultivation. If phosphorus is needed, application should be made before planting time. Potassium can be applied at planting time. A minimum of 37 to 56 kg/ha of P is needed for production of castor, and 15 to 19 kg/ha of K.

Where pre-plant furrow irrigation is applied, castor plants should not require irrigation until the first racemes appear on the plant. Under normal conditions, 12 to 14 days between irrigations should keep plants from stressing for moisture, but high temperatures and high winds during the peak growing and fruiting periods may cause the plants to need more frequent irrigation. Castor requires 20.6 to 24.7 cm/ha of water annually to produce high yields. The time of last irrigation is usually from 1 to 10 Sept. **** Writers Note (These figures are for the commercial varieties grown in both Europe and America, and do not reflect the advantages of using local varieties in the arid and semi arid regions that have become adapted to the local conditions)**

Cultivation is much the same as for controlling weeds in cotton or soybeans. Rotary hoes are often used before or after the plants emerge to control small annual weeds and grasses. Cultivation with sweeps should be as shallow as possible to prevent damage to the fibrous root system of the plants.

3.3 Environment Requirements

3.3.1 Climate

Castor beans grow best where temperatures remain fairly high throughout the growing season of 140 to 180 days. The soil must be able to warm up early in the spring. The seed may fail to set, however, if the temperature stays above 100°F for an extended period.

3.3.2 Soil

The crop requires a loamy soil of medium texture. **Castor beans do well on either alkaline or acid soils, as long as the subsoil is permeable and there is good drainage.** Seed will not set if soil moisture is inadequate. Castor beans should not be planted in an area that is subject to erosion.

3.3.3 Seed Preparation and Germination:

Seeds should be cleaned to remove foreign material, seeds with attached hulls, and damaged seeds. They should also be treated with a fungicide before planting. This is particularly important where there is a risk of low spring temperatures and high soil moisture immediately after planting. Thiram is the only registered seed treatment fungicide for use on castor beans.

3.3.4 Seeding Date

Castor beans should be planted in early May, about the same time as corn. Seedlings will emerge in 10 to 21 days.

3.3.5 Method and Rate of Seeding

Good stands of castor beans require fairly heavy planting rates, because germination of the seed is usually rather low. Seeding at 10 to 14 lb/acre will give a good stand, depending on the seed size and the height of the variety. Row width should be 38 to 40 in. with 8 to 12 in. between plants. Because of differences in germination rates and plant size, growers should calculate rates based on the seed lot. Seeds should be planted at a depth of 1 1/2 to 3 in.

Because castor beans are oily and easily broken, they can clog machinery and cause irregular spacing. Most corn planters with an air metering system should perform well. Planters using metering plates will require plates with proper cell size. Always check the planting unit to ensure that excessive bean cracking or crushing is not occurring during planting.

3.3.6 Fertility and Lime Requirements

Castor beans grow well on slightly alkaline or acid soils. The most important factor in fertility level is the supply of nitrogen in the soil. Insufficient nitrogen results in reduced castor bean yields. 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, as shown in Table 1. Preplant and side dress applications of nitrogen may be beneficial at the higher application rates or on lighter-textured soils.

In general, castor beans require the same amount of nutrients as other low-demand field crops. For typical silt loam soils testing in the optimum range (6 to 10 ppm P; 81 to 100 ppm K), approximately 20 lb P₂O₅ and 40 lb K₂O should be applied per acre. If soil tests are below optimum, approximately 5 lbs P₂O₅ and 20 to 30 lb K₂O should be applied in addition to the previous amounts. Castor beans do not generally respond to phosphorus, and excess soil phosphorus levels can actually decrease yields. Therefore, do not apply P₂O₅ except where soils test in the optimum or below optimum level for extractable P.

Table 1: Nitrogen recommendations for Castor Beans.

Soil Organic Matter	Nitrogen Application Rate
%	lb/acre
< 2	100
2–4.9	80
5–10	60
> 10	40

3.3.7 Variety Selection

Castor bean varieties have been developed to produce large yields of seed with a single harvest. The tall varieties may reach a height of 10 ft or more. The dwarf types seldom exceed four or five ft. **DOVE BIOTECH** through extensive research in arid and semi arid regions in both Africa and South America found that the local varieties are the gene stock that should be used for the **Biodiesel** projects in arid and semi arid regions.

3.4 HARVESTING

The castor bean crop is ready for harvesting when all the capsules are dry and the leaves have fallen from the plants. Delay in harvesting after the crop is ready may result in losses from "shattering," in which the seeds pop out of the capsules.

Since castor beans are very susceptible to cracking and splitting during harvest, adjustment of the combine cylinder speed and cylinder-concave clearance is very important. Usually, a low cylinder speed and wide cylinder concave clearance are recommended. Combine operators should frequently inspect harvested beans for breakage.

Weeds cause problems in the castor bean harvest. They may clog machinery or push in front of the harvester and cause shattering of the castor beans. Volunteer corn plants present no special problem in the harvesting operations, but do add foreign material to the yield.

After harvest, break up the stalks mechanically and work them into the soil. The stalks deteriorate rapidly and furnish organic matter. Castor bean hulls, which are scattered over the field during harvest, are about equal to barnyard manure in fertilizer value. Seeds left in the field after harvest may cause a volunteer problem in the next year's crop. Waiting until seeds germinate and then disking the young plants down will prevent this to some extent. Follow castor beans with a row crop or a grain crop, for which the volunteer castor bean plants will not present a problem.

3.4.1 Drying and Storage

Moisture content, foreign material and cracked or broken beans are considered in grading the seed. Ideally, castor beans should be stored at less than 6% moisture.



(Oil Bearing Seeds Of the Castor Bean)

4.0 OIL FROM THE CASTOR BEAN SEEDS

The seeds are collected when ripe: as the capsules dry, they open and discharge the seeds. The oil is obtained from the seeds by two principal methods - *expression* and *decoction*. The latter process is largely used in India, where the oil on account of its cheapness and abundance, is extensively employed for illuminating, as well as for other domestic and medicinal purposes.

The oil exported from Calcutta to Europe is prepared by shelling and crushing the seed between rollers. The crushed mass is then placed in hempen cloths and pressed in a screw or hydraulic press. The oil, which exudes is mixed with water and heated till the water boils and the mucilaginous matter in the oil separates as a scum. It is next strained, then bleached in the sunlight and stored for exportation.

There are two modes of extracting the oil by *expression*:

- 1) Without heat, when it is termed 'cold drawn Castor Oil,' this process being largely carried out in Italy, Marseilles, Belgium, Hull and London;
- 2) With heat, the process generally adopted in America.

Although monotypic, the castor plant can vary greatly in its growth habit and appearance. Some castor plants are perennials, which can take the size of small trees; other plants are dwarf types and are grown as annuals. There also exists an enormous variation in leaf shape and coloring, which has led to a selection by breeders for use as ornamental plants.

Castor seed contains between 40% and 60% oil, which is rich in tryglycerides, mainly ricinolein. Global castor seed production is around 1 million tons per year. Leading producing areas are India, China, Brazil and the former USSR. There are several active breeding programmes for castor.

In America, where the oil is obtained by expression with heat, the manufacture is conducted on an extensive scale in California. There the seeds are submitted to a dry heat in a furnace for an hour or so, by which they are softened and prepared to part easily with their oil. They are then pressed in a large powerful screw press, and the oily matter, which flows out, is mixed with an equal proportion of water, and boiled to purify it from mucilaginous and albuminous matter. After boiling about an hour, it is allowed to cool, the water is drawn off and the oil is transferred to zinc tanks or clarifiers capable of holding from 60 to 100 gallons. In these it stands about eight hours, bleaching in the sun, after which it is ready for storing. By this method, 100 lb. of good seeds yield about five gallons of pure oil.



In the tropics and sub tropics, the castor bean plant is a perennial. It is grown as an annual in temperate regions, however, requiring a growing season of 140 to 180 days. Germination is slow. Seedlings will emerge 10 to 21 days after planting. Commercial varieties grow to a height of 3 to 10 ft.

The plant consists of several stems or branches, each terminated by a spike. The mature spike is six to 12 in. long. In some varieties, female flowers are on the upper part of the spike and male flowers on the lower part. Other varieties have male and female flowers interspersed on the spike. Varieties with spikes of only female flowers have made possible the production of hybrid seed. Male flowers drop off the spike after pollination.

The lower spikes on the plant mature first, followed by the upper spikes. Each spike bears 15 to 80 capsules, which may be prickly or smooth on the outer surface. The capsules, which develop from the female flowers, contain three seeds each and explode when ripe.

The seeds may be egg-shaped, oblong, or round, usually with an enlargement on one end, called the caruncle. Seeds vary in size, but most commercial varieties average 1,000 to 1,500 seeds/lb.

4.1 Oil Expression Methods

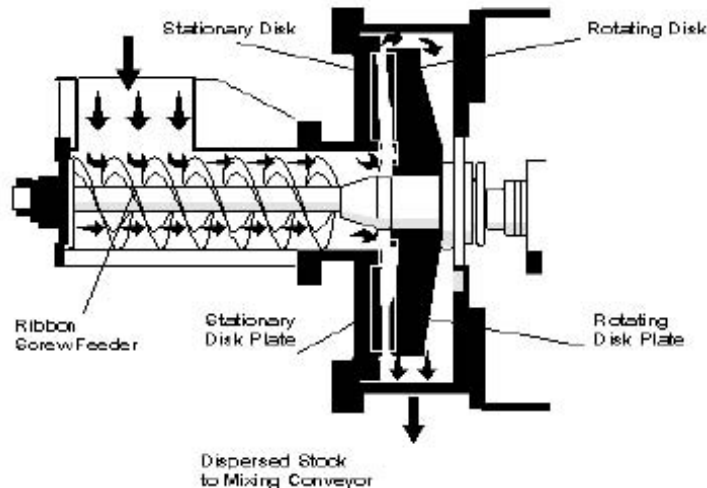
Castor oil is derived from the seed of *Ricinus communis* L. which grows in tropical or subtropical regions such as Central Asia, Tanzania, Brazil, and Southern Kazakhstan to name a few. It occurs as a perennial or annual plant and is considered a drought resistant crop in India (Moshkin, 1986). Unfortunately in 1972, economic pressures created circumstances, which led to the United States losing its domestic supply of castor oil, and the US became dependent on foreign countries for both the seed and the oil. As of 1991, any castor seed produced in the US has to be shipped to Mexico for expression of the oil from the seed (Browning, 1991). As a result, the US is many years behind in the expression technology. However, the expression of the oil from this seed is done in a similar manner to most other oil seeds. The seeds are collected when ripe: as the capsules dry, they

open and discharge the seeds. The seeds are then cleaned, decorticated, cooked and dried prior to extraction. Cooking is done in order to coagulate protein, which is necessary to permit efficient extraction, and to free the oil for efficient pressing. It is done at 80°C, under airtight conditions. After cooking, the material is dried at 100°C, to reach a moisture content of approximately 4 percent.

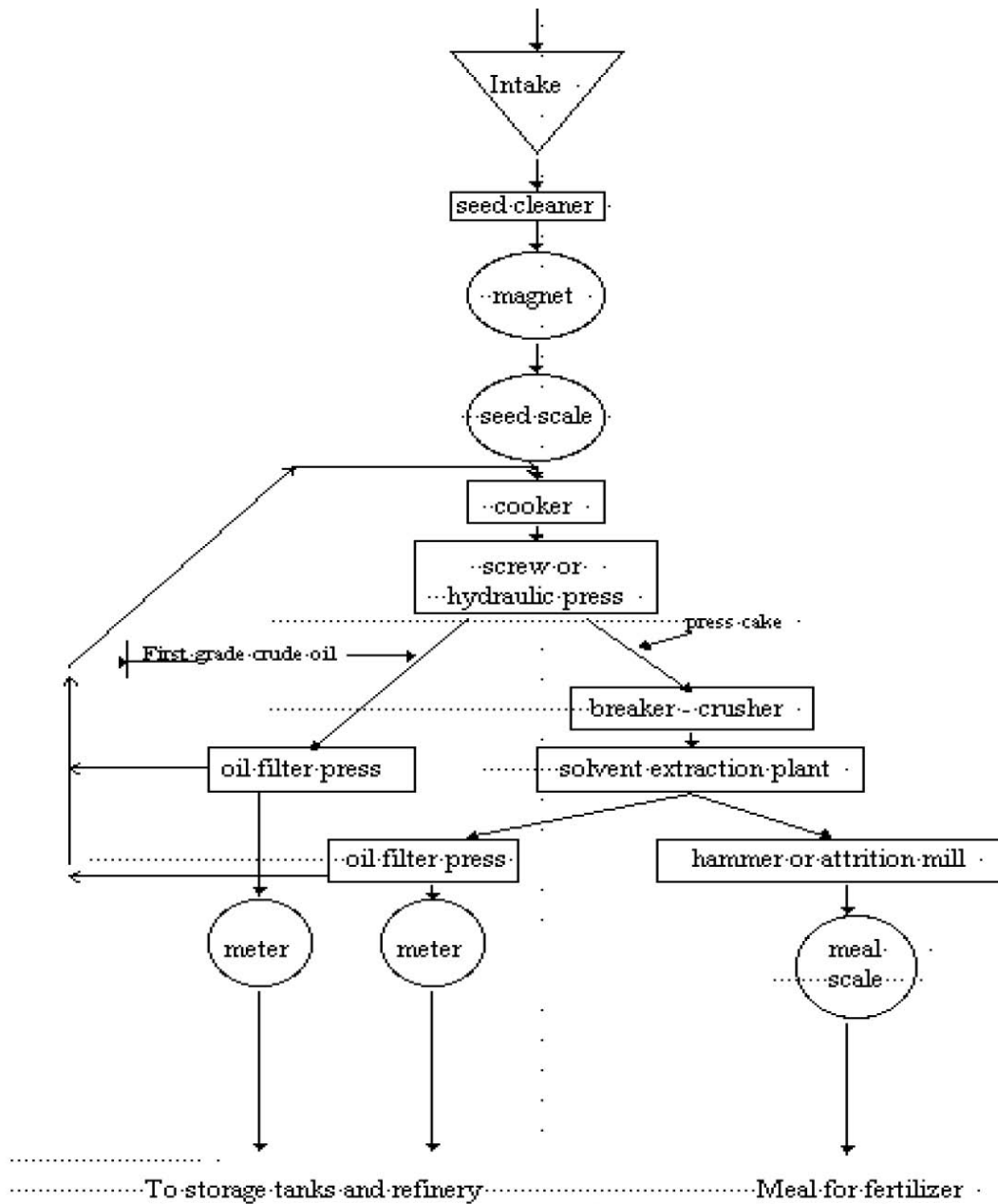
First stage of extraction is pre-pressing pressing using a high pressure continuous screw press - expeller. The expeller usually consists of a barrel containing a stainless steel helical screw. The pitch of the screw flights gradually decreases towards the discharge end, to increase the pressure on the pulp as it is carried through the barrel. (Fellows, 1996).

Extracted oil is filtered, and collected in a settling tank. Material removed from the oil, called foot, is fed back into the stream of fresh material. Material discharged from the press, called cake, contains 8 to 10 percent oil. It is crushed into coarse meal, and subjected to solvent extraction with hexane or heptane. Continuous processing is used, based on the principle of counter current flow of solvent and oil bearing material. The oil is removed effectively, as the material comes into contact with increasingly purer solvent. After extraction, solvent is removed by distillation, and the resulting oil is processed in similar manner as oil from the pressing step. (Weiss, 1971) The screw press diagram:

Modular Fig. 14.2.7a



The flow sheet for castor seed oil extraction with pre-pressing and solvent extraction.



5.0 CASTOR BEAN AGRONOMIC MODEL

Budget presented for 1Ha under medium management level, semi arid regions.

- The producer price per kg of castor bean seed is quoted at € 0.42 per Kg (as at August, 2003)
- Table1. Input Costs,
- Table2. Variable Costs and Net return on Sales

TABLE 1 INPUT COSTS

Seed per hectare	€\$ 0.42	Water per hectare	€\$ 8.31
Labor per hectare	€\$ 0.33	Tractor Hire per hectare	€\$ 5.32
Herbicide	Nil	Pesticide	Nil
Oxen hire	€6.64	Fertilizers	Nil
Harvest per hectare	€ \$ 19.93	Fuel per hectare	€\$ 4.15
Insurance	Nil	Transportation	€\$1.00

TABLE 2 IMPUTE COSTS + VARIABLE COSTS + NET RETURN PER HECTARE

OUTPUT		UNITS	
YIELD KG		2000 KG PER HECTARE	
OUTPUT AT QUOTED PRICE OF €\$0.42 / KG (2500 K)		€\$ 830.56 (5,000,000 k)	
VARIABLE COSTS PER HECTARE	UNIT	QTY	COST PER HECTARE
SEED	KG	4.5	€\$1.87 (11,258 K)
LABOR	MAN DAYS	70	€\$ 23.26 (140,000 K)
TRACTOR HIRE	HRS	4	€\$ 21.26 (128,000 K)
TRANSPORTATION	KG	2,000	€\$ 33.22 (200,000 K)
TOTAL VARIABLE COSTS PER HECTARE	HECT.	€	€\$ 79.61 (479,258 K)
TOTAL IMPUTE COSTS PER HECTARE	HECT.	€	€\$ 46.10 (277,522 K)
CASTOR SEED OIL PRODUCTION PER HECTARE	KG	450 GRAMS PER KG	900 KG CASTOR OIL
LITERS OF CASTOR OIL PER HECTARE	LITER	1	990 LITERS
CASTOR OIL COST PER KG INCLUDING CRUSHING	LITER	1 LITER	€\$ 0.13 / LITER
CASTOR OIL TO BIODIESEL PRODUCTION COSTS / KG	LITER	1 LITER	€\$ 0.15 / LITER
TOTAL PRODUCTION COSTS	LITER	1 LITER	€\$ 0.28 / LITER
BIODIESEL WHOLESALE	LITER	1 LITER	€\$ 0.65 / LITER
NET RETURN ON BIODIESEL SALES	LITER	1 LITER	€\$ 0.37 / LITER
NET RETURN PER HECTARE	HECT.	€	€\$ 366.30 / HECTARE

6.0 CONCLUSIONS



Although castor is probably **indigenous to Eastern Africa**, today castor is distributed worldwide. Castor establishes itself easily as a "native" plant and can often be found on wasteland, near rail roads and has recently also been used extensively as decorative plant in parks etc. Castor seed contains between 40% and 60% oil, which is rich in tryglycerides, mainly ricinolein and provides a great natural resource for Biodiesel production.

Global castor seed production is around 1 million tons per year. Leading producing areas are India, China, Brazil and the former USSR. There are several active breeding programmes for castor.

Dove Biotech visualises that Castor Bean in arid or semi arid regions using local varieties, can provide a valuable resource for Biodiesel production. This type of holistic agricultural approach provides the regional farmers and local Biodiesel industry with two strategic benefits;

- 1) For the regional farmers the planting and harvesting of local varieties of Castor Bean on marginal lands provides the farmers with not only additional income, but also provides stabilization of marginal lands that are susceptible to erosion and through either water or wind.
- 2) The local Biodiesel industry benefits in that they are guaranteed a continuous supply of raw material for the production of Biodiesel which in turn, gives viable economics to the local Biodiesel industry overall.



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