Mechanization of

CASTOR BEAN

Harvesting

by

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Castor beans were originally a native of the tropics. However, they will grow in a wide variety of soil and climate conditions. They produce abundantly with a long growing season under favorable growing conditions. Considerable acreages were grown in the United States before the turn of the century. Because of low yielding varieties and hand harvesting methods, the acreage was eventually replaced with more profitable crops.

Recently, castor beans have become established as a crop in many areas of the United States and have become competitive with other crops. This has been made possible because of recent machinery developments and the availability of efficient harvesting equipment, also the development of high yielding varieties of castor beans that are suitable for mechanical harvesting.

The production areas where castor beans are grown at the present time are shown in Figure 1. Other areas suitable for growing castor beans will appear in the years to come.

Crop Potentials

The present annual requirements of castor beans to furnish the castor oil needs for this country are approximately 250 million pounds. New uses that are continually being developed along with the demands from an increasing population are having an impact for additional requirements. The yearly domestic production of castor beans during the last three years has ranged from about 10 to 16 percent of the annual consumption. Castor bean acreage is expected to increase during the years to follow under the present crop prices.

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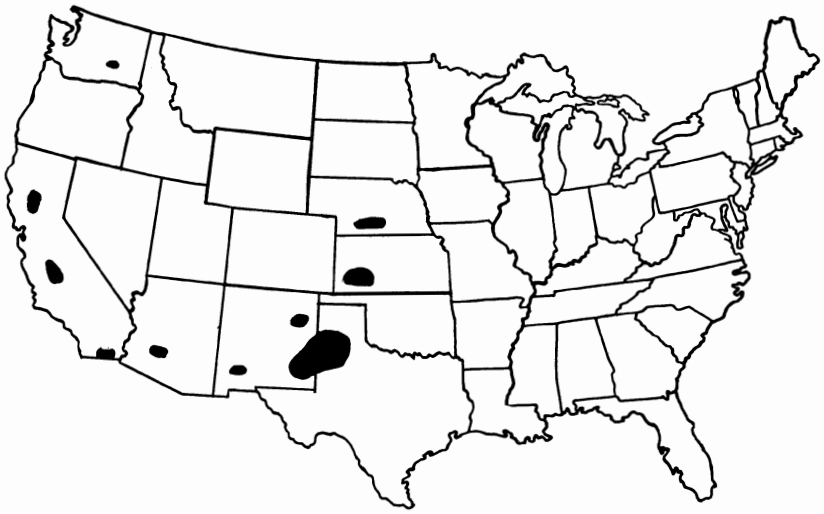


Figure 1. Areas of Castor Bean Production

Information furnished by industry, The Baker Caster Oil Company, Castech, Inc., and Pacific Vegetable Oil, Inc.

1960 ACREAGE

Location	Acres	Production *(pounds)*
Arizona	310	360,000
California	1,650	2,890,000
Kansas	1,760	2,310,000
Nebraska	950	1,270,000
New Mexico	3,300	2,680,000
Texas	18,850	21,530,000
Washington	80	130,000
Total	36,900	31,170,000

The Castor Bean Plant

Two types of castor beans, dwarf and normal internode varieties, are grown in the United States. The dwarf internode varieties are grown under irrigation and range in height from three to five feet (Figure 2) at harvest time. At the present time they are grown mainly in the central United States. Yields under good growing conditions range from 1800 to 3000 pounds per acre. The normal internode varieties grow to heights of six to twelve feet depending on variety and growing conditions (Figure 3). The normal internode varieties are grown mainly on the west coast. Yields over 2000 pounds per acre are common when grown under irrigation although yields of 3500 pounds per acre or more have been produced.

Figure 2. A Field of Dwarf Type Castor Bean Plants

Figure 3. A Field of Normal Internode Type Castor Bean Plants

Some varieties of castor beans produce one main heavy stem which terminates into a large spike. The lateral branches are much smaller and may also produce a number of smaller spikes during the growing season. Other varieties produce a number of branches on which several settings of spikes are produced during the growing season.

Present varieties of castor beans are best suited for growing in the dry climates under irrigation. Good yields are produced with a growing season of at least 140 days. However, higher yields are possible with longer growing seasons. Castor beans grown without irrigation should be normal internode varieties to better insure a growth of plants suitable for mechanical harvesting.

Dwarf varieties of castor beans under most conditions are planted to produce a uniform stand of twelve-inch plant spacing for optimum yields and desirable plant shape and growth suitable for harvesting. Tall internode varieties of castor beans are planted to a wider stand of approximately fifteen inches to prevent excessive rank plant growth.

Mature seed contains about fifty percent oil by weight. The oil is used as a chemurgic raw material for many products. The residue remaining after the oil has been extracted from the seed is known as castor pomace and is used mainly as an organic fertilizer.

Cultural Requirements for Harvesting

Castor beans grow best on well drained sandy loam soil with adequate fertilizer and water. Land preparation before planting should be similar to that for cotton. Castor beans are slow to germinate and should be planted in moist, firm soil, covered uniformly and deeply enough to prevent drying out of soil and to promote even germination and growth. They should be planted on beds when the soil becomes warm and after danger of frost.

Shallow cultivation practices which will control weeds with a minimum damage to the castor bean plant root system are essential for good harvesting conditions. The last cultivation should provide a wide furrow half way between rows and of uniform depth to accommodate the harvester wheels.

Irrigation and fertilizer practices are an essential part of producing optimum growing conditions and yields. Optimum growing conditions are required at all times to prevent plant stress and reduce the incidence of diseases.

Harvester Development

Development of the first complete castor bean harvesting machine was made at the University of Nebraska* The machine was designed as a one-row pull type harvester. It embodied two parallel beaters mounted side by side at an angle of approximately 45 degrees to the ground for the purpose of removing the seed in capsules from standing stalks. The machine included a cleaner for separating broken stalks, loose leaves, and other foreign material from the seed capsules, also a bin for carrying the harvested seed capsules (Figure 4).

In 1949 a cooperative program was started by Agricultural Engineers at the Oklahoma Agricultural Experiment Station and U. S. Department of Agriculture to develop castor bean harvesting machinery. The next several years were spent in developing first a one-row and then a two-row harvester using stripping principles similar to the Nebraska machine (Figure 5) (6).

Figure 4. Experimental Castor Bean Harvester Built at the University of Nebraska

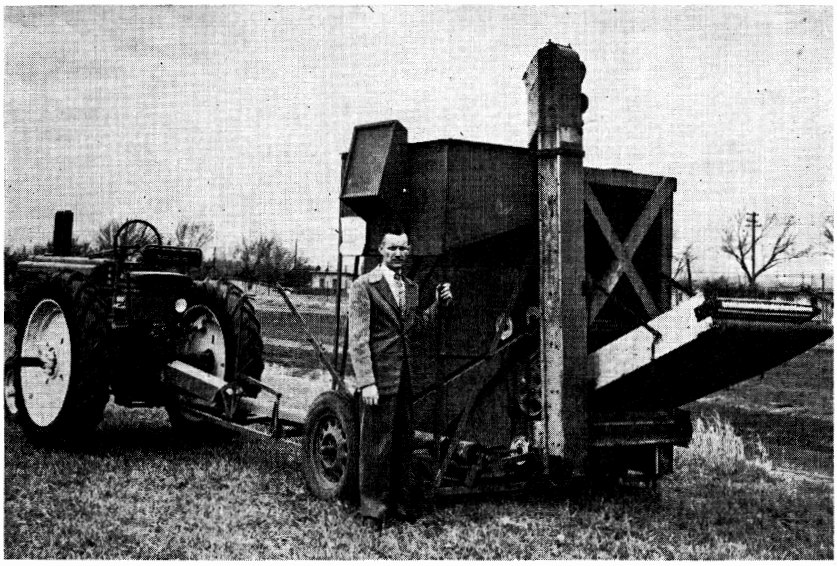
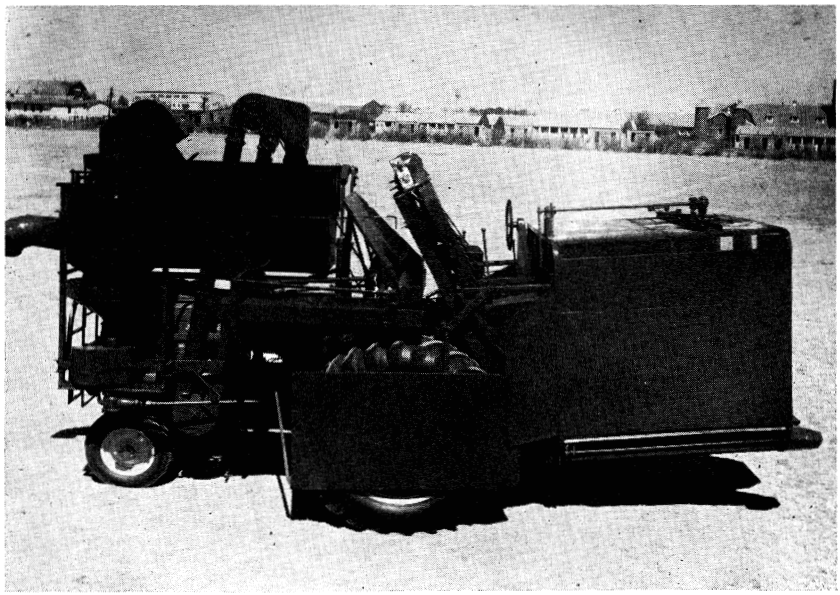


Photo furnished by the Agricultural Engineering Department, University of Nebraska.

*Financial assistance by Nathan Gold of Lincoln, Nebraska, and the Baker Castor Oil Company of Bayonne, New Jersey.

Figure 5. Oklahoma Agricultural Experiment Station and United States Department of Agriculture Stripper Type Castor Bean Harvester.

Figure 6. Oklahoma Agricultural Experiment Station and United States Department of Agriculture Prototype Castor Bean Combination Harvester-Huller.



In 1954 and 1955, a prototype harvester employing many of the principles used in present harvesters was developed (Figure 6) (7). This machine not only removed the seed capsule from the plants but removed the hull from the seed and placed the clean seed in a bin on the machine. During this same period from 1949 through 1955 some development work and a few machines were built by other interested individuals and concerns; however, the work was brief and was later discontinued.

Castor Harvesters of Today

Five different manufacturers have castor bean harvesting machines which are being used at the present time. Production on an experimental basis was started by one of these companies in 1956. During the last four years approximately one hundred castor harvesting machines have been produced by the following manufacturers:*

Deere & Company, Moline, Illinois

Ebeling Machine Shop, Plainview, Texas

Hopper Machine Works, Bakersfield, California

Jungbauer Machinery & Manufacturing Company, Phoenix, Arizona

Farrar Brothers, Hugoton, Kansas

The harvesters built by all of these companies remove the seed capsules from standing plants grown in rows. They also hull and clean the seed and deposit the clean seed in a bin on the harvester (Figure 7).

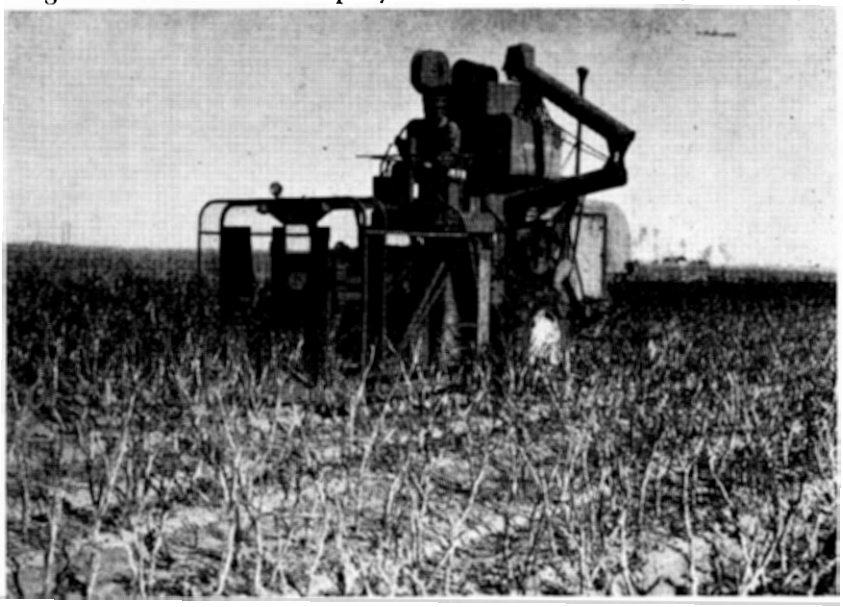
The castor harvester made by Deere and Company consists of an attachment which mounts onto their two-row combine (Figure 8). The changes consist mainly of replacing the combine header, cylinder and concave, clean grain elevator, and removing from the separator the regular straw walkers and beater behind the cylinder. Essentially the attachment is made up of a two-row header, rubber-covered hulling cylinder, rubber concave, and a bucket-type clean bean elevator. The header can be accommodated to the harvesting of short (dwarf) or tall (normal internode) castor plants grown in 38- to 40-inch rows .

The current model of the Ebeling Machine Shop harvester consists of a four-row attachment that has been adapted for use on the Deere, International, and Massey-Harris combines (Figure 9). The harvester header uses sloping stationary row brush seals with knockers placed be-

*Mention of trade names does not imply any particular endorsement.

Figure 7. Hulled Castor Beans Loaded in Truck Box from Castor Bean Harvester.

Figure 8. Deere and Company Castor Bean Harvester (Two-Row)



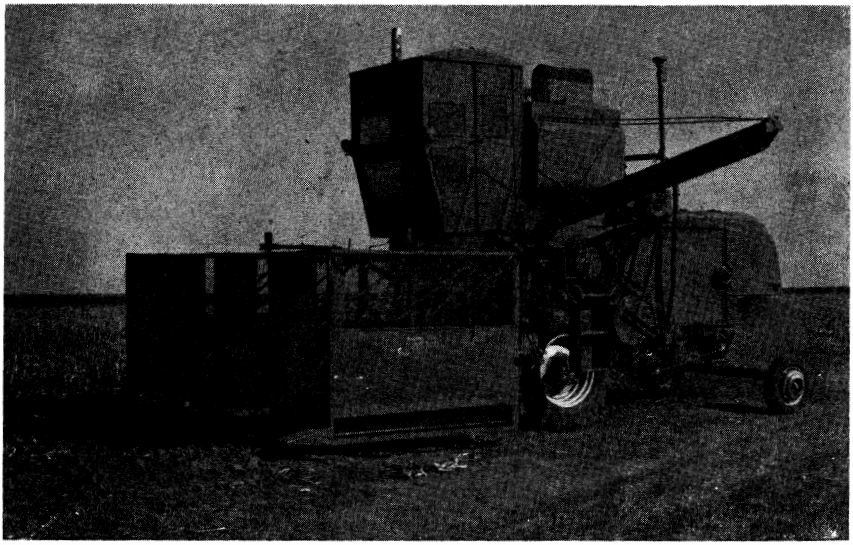


Figure 9. Ebeling Castor Bean Harvester (Four-Row)

low the brushes. Auger conveyors move the seed capsules to the hulling unit. Two rubber covered drums rotating toward each other at different speeds are used to hull the seed. The combine cleaning system is used to separate the hulls and trash from the seed. A bucket elevator is used to convey the hulled seed to the harvester bin.

The Hopper Machine Works has a two-row self-propelled and tractor mount harvester to harvest both tall and short castor varieties (Figure 10) (8).

The Jungbauer Machinery and Manufacturing Company has a two-row tractor mounted harvester which has attachments for mounting on International Harvester, John Deere, and Allis Chalmers tractors. This machine employs the same general principles of harvesting castors as the USDA prototype machine (Figure 11).

Farrar Brothers of Hugoton, Kansas, have an experimental two-row castor harvester attachment for mounting on the Gleaner and International Harvester combine. This machine employs harvesting principles used in other castor harvesters with the exception that the machine uses air for conveying unhulled seed and cleaned seed (Figure 12).

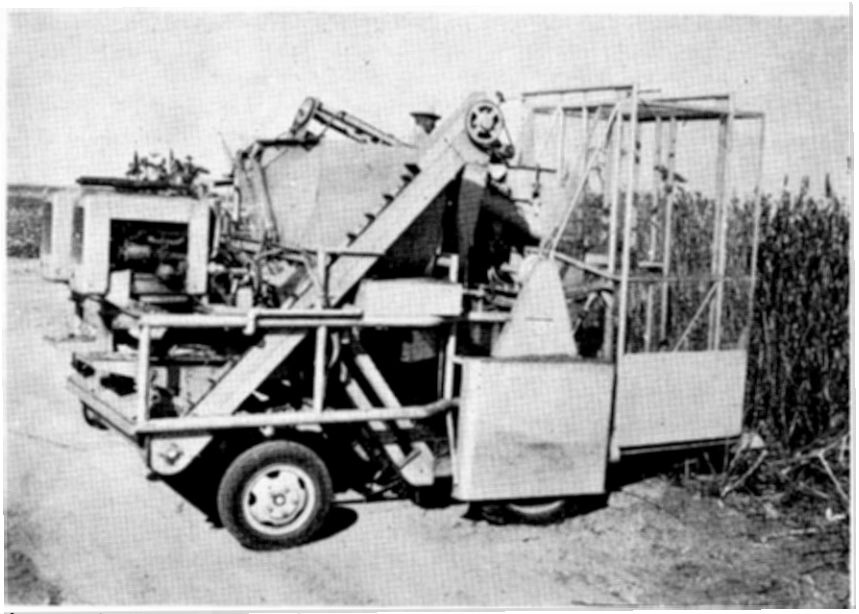
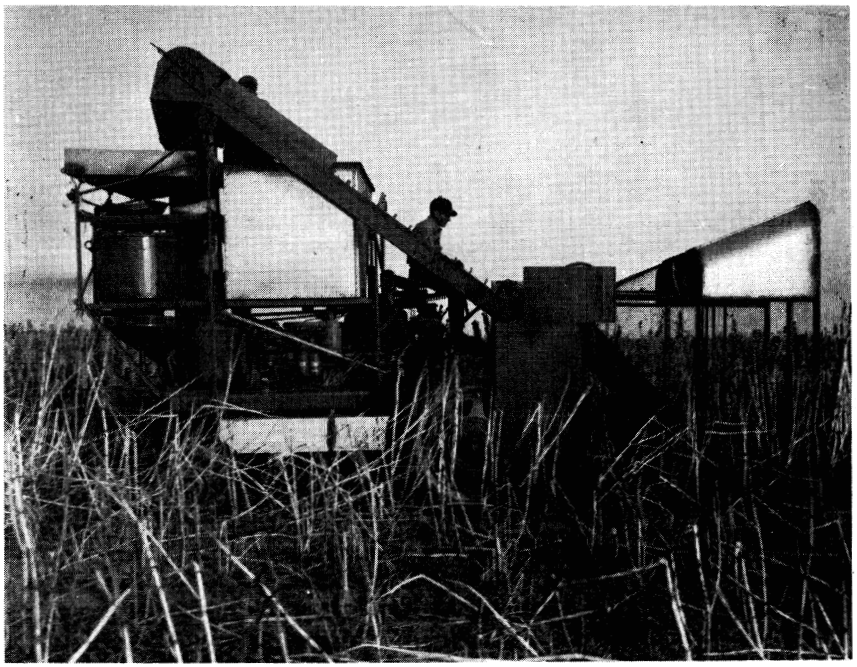


Figure 10. Hopper Machine Works Castor Bean Harvester (Two-Row).

Figure 11. Jungbauer Machinery and Manufacturing Company Castor Bean Harvester



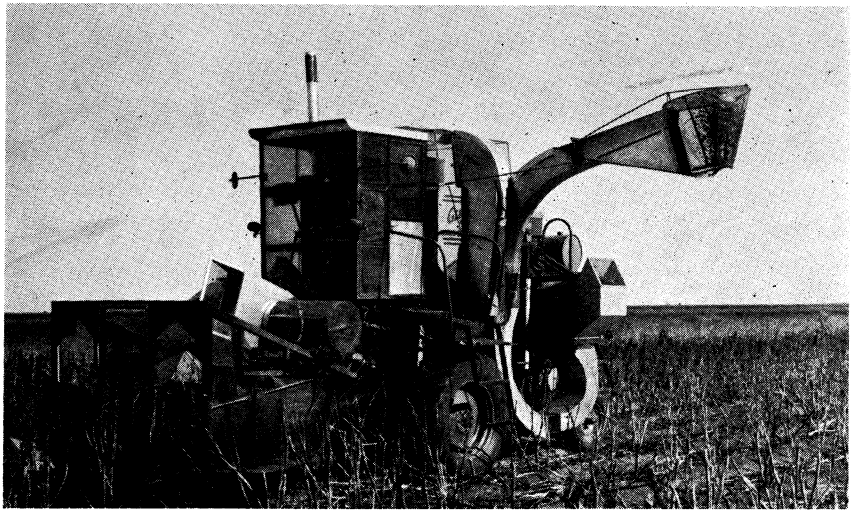


Figure 12. Farrar Brothers Castor Bean Harvester

Conditioning the Crop for Harvesting

The present equipment is designed to harvest when seed capsules and plant leaves are dry and when the relative humidity is below 45 percent. At harvest time the plants are still growing and capsules are in all stages of development. Some are mature and dry, others are green and immature. The green capsules must be dried and the leaves removed before harvesting the crop. This is accomplished by killing frosts or by defoliation. Castor beans usually are ready for harvest about ten days after killing frost.

In areas where killing frosts are not early enough for harvest, airplane applications of chemical defoliants are made 10 to 15 days before harvest. A mixture of dinitro general in weed oil is usually successful when maximum daily temperatures are above 85°F. The usual mixture is one quart of dinitro general in 10 to 17 gallons of oil per acre where a single application is made. If it is anticipated two applications should be needed, the first application should be one pint of dinitro in 10 gallons of oil; and the second application one pint dinitro in 7 gallons of oil. The first application should be made two weeks before harvest, and the second, one week before harvest. Since dinitro is less effective at lower temperatures, when daily maximum temperatures drop below

85°F., pentachlorophenol has been used at a rate of ½ to 1½ pounds of actual ingredients per acre (1). New chemicals are showing promise of being effective under wider weather and crop conditions; however, further evaluation needs to be made to determine their effectiveness.

Castor beans grown in areas such as Texas, Kansas, Oklahoma, Nebraska, and New Mexico are harvested after frost. Castor beans grown in Arizona and California are usually defoliated by chemicals to dry the leaves and capsules to condition the crop for harvest.

Harvesting

The acreage that can be harvested in one season by any one harvester will vary. Usually, a two-row machine can harvest 450 acres during one season in Texas. In states further north where less favorable harvesting weather usually occurs, the number of acres that can be harvested by one machine in a season will normally be less. Some growers plan to harvest 300 acres per two-row machine in Kansas and Nebraska. The length of the harvesting season in the west coast states can be controlled to some extent where chemical defoliation is used to condition the plants. Once castor beans are in condition for harvesting after frost or defoliation, they should be gathered to avoid seed shatter in the field from hazards of wind, wet weather, and low temperatures.

The present harvesting equipment is designed to harvest castor beans after all of the capsules and leaves are dry and before the plant stems become brittle. When in this condition, the seed capsules are easily shaken from the plants. Seed capsules must be dry to hull properly, otherwise excessive breakage of seed occurs. Figure 13 shows the component parts of the castor bean spike and the damage to the seed which can occur during harvesting.

Castor seed should be handled gently to avoid seed breakage. Broken or cracked seed will become rancid and affect the quality of oil produced. In addition, once this high oil bearing seed is broken, it will emit oil and coat material which it contacts. Late in the harvest season oily material will cause build-up on conveyors when temperatures drop below 60°F. The lower temperatures cause the build-up to become excessive unless certain precautions are taken. Proper adjustment of the huller to minimize the number of broken seed and application of heat to conveyors at points of build-up to prevent sticking is essential for satisfactory operation.

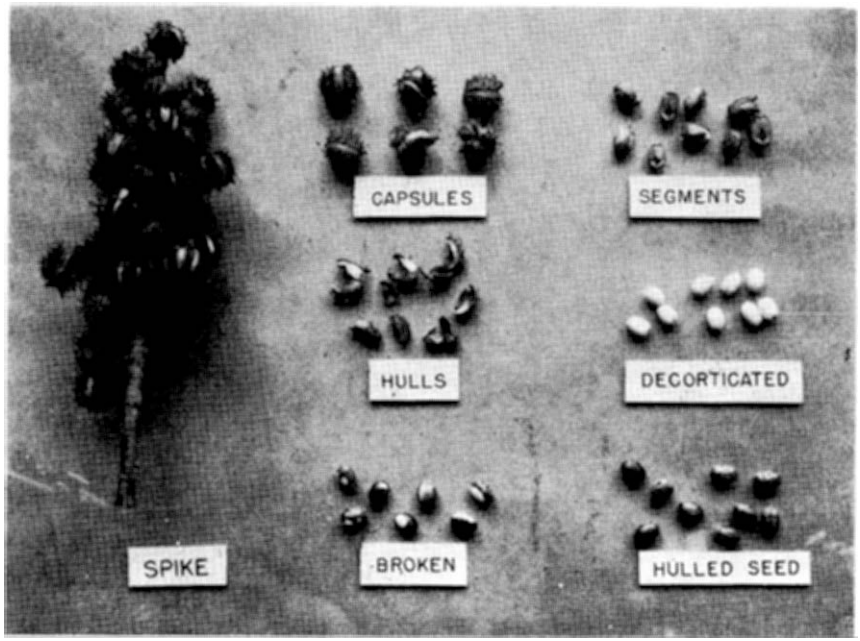


Figure 13. Parts of the Castor Bean Spike, and Damage that can Occur During Harvesting

The harvesting operation consists of removing the seed capsules from standing plants by use of a low-frequency vibration induced in the plants. This is accomplished by use of a beater mechanism that hits the plants near their base directly under the bottom castor spike. The hulls are removed in a machine which rolls the hulls off the seed between two rubber surfaces having a differential motion. The hulls are separated from the seed with a cleaning device and blown out of the machine onto the ground. The clean seed is then elevated into a storage bin mounted onto the harvester.

Distribution of the hulls back onto the land returns valuable nutrients to the soil. Castor bean hulls are shown to have approximately 1.64 percent nitrogen, .082 percent phosphorus, and 3.81 percent potassium (2).

Castor bean harvesters are specialized machines. They range in price of approximately $3500 for a two-row attachment to mount onto a combine to over $15000 for a two-row self-propelled machine. Custom charges for harvesting in 1960 were 1¼ cents per pound (based on clean seed) in the western states and ¾ cents per pound in the mid-central states.

Harvesting losses can be kept below five percent by observing proper machine adjustment and employing a good operator, provided good crop and weather conditions exist. However, due to the nature of the crop, harvesting losses can become excessive with careless and improper machine operation, particularly when the seed is dry. Field harvesting studies in 1960 on dwarf castor beans showed losses increased as machine travel increased. The losses were 4.8 percent at 1½ miles per hour, 8 percent at 3 miles per hour, and 9.7 percent at 4½ miles per hour (3).

Harvesting Recommendations

1. Adjust header to fit the row spacing of plants.
2. Harvest only when seed capsules are dry so all of the seed can be gathered and hulled.
3. Stay on row to prevent seed from being thrown out of header.
4. Drive slowly enough so all seed is removed from the plants and fall inside the header.
5. Adjust huller clearance during the day as conditions require to prevent an increase in seed breakage.
6. Keep hulling surfaces true and in good condition.
7. Adjust knockers to remove all seed capsules but not to break the plant stalks.
8. During periods of low temperatures, apply heat from engine exhaust or other sources to oily build-up areas on conveying equipment. Use only the amount of heat needed to prevent the oily build-up, as excessive amounts of heat are undesirable.
9. Harvesters and all handling equipment should be thoroughly cleaned of castor seed before the equipment is used for other purposes, as castor beans are considered poisonous to man and livestock.

Conveying Hulled Castor Beans

Screw augers, belts, buckets, and air conveyors have all been used to convey hulled castor beans. Proper design and operation are essential if seed breakage is to be kept to a minimum. Because of their simplicity, screw augers have a wide use in conveying castor seed. When screw augers are used, they should have a minimum of one-half inch clearance between the periphery of the auger flight and the inside of the pipe. The auger should be straight and run true, and the flighting should have a smooth polished surface. Hangers in the pipe are objectionable and should not be used. Bucket and belt conveyors have been used and have a wide acceptance. The use of air conveyors for moving castor seed may easily result in rougher handling of the seed and cause excessive seed breakage. Every precaution should be taken to prevent seed breakage. At low temperatures, residue build-up becomes a problem with increased seed breakage. Down time in removing residue build-up can be eliminated or greatly reduced by use of adequate heat on the areas where build-up takes place.

Economics of the Crop – Costs & Returns

Castor bean prices are based on world market prices and are primarily influenced by the major producing countries—Brazil and India. Prices during 1959 and 1960 have been about 6.5 cents per pound delivered to the mills located at either the west or east coast of the United States. The prices received by growers delivered to load-out equipment in the area where castor beans are grown ranged from 5.0 to 5.3 cents per pound.

Production costs of castor beans in the U. S. vary over a wide range between production areas. On the west coast where the plants must be defoliated to condition the crop for harvest, the cost is estimated to be $126.75 per acre (Table 1) (4). Estimated production costs for castor beans grown in the mid-west where frost is dependent upon to condition the crop for harvest amount to $55.31 per acre (Table 2) (5).

Table 1.—Cost to Produce Castor Beans in California (4).

Operation and Material	Time Spent *hours*	Costs Per Acre: Labor *(dollars)*	Equipment *(dollars)*	Other *(dollars)*	Total *(dollars)*
Cultural					
Land Preparation	2.0	2.60	2.00		4.60
Plant and Fertilizer (two men)	.5	1.15	.50		
Seed: 12 lbs. @ 40¢/lb.				4.80	
Nitrogen: 80 lbs. @ 12¢/lb.				9.60	16.05
Irrigation					
One pre and 5 crop	12.0	12.00	2.50		
Water: 2½ ft. @ $6.00/ft.				15.00	29.50
Hoeing	4.0	4.00			4.00
Cultivating (two cultivations)	1.0	1.30	1.00		2.30
Taxes				12.50	12.50
Miscellaneous Overhead		3.60	2.70	3.50	9.80
Harvest					
Defoliation (Avg. of 1½ applications)					
1½ qts. dinitro and 22 gal. diesel fuel				7.50	7.50
Plane: $2.00/application				3.00	3.00
Harvest (3000 lbs. @ 1¢/lb.)				30.00	30.00
Hauling (3000 lbs. @ $5.00/ton)				7.50	7.50
Total Costs*		24.65	8.70	93.40	126.75

*Costs exclusive of depreciation and interest on equipment, tractor 5½ hours, irrigation facilities, and land.

Table 2.—Cost to Produce Castor Beans in the Midwest (5).

Operation and Material		Total Costs Per Acre *(dollars)*
Seed: 15.5 lbs.		2.25
Power and Machinery:* 2.8 Hrs.		7.31
Irrigation Water:** (5 applications)		6.10
Fertilizer: 122 lbs. Nitrogen		10.42
Insecticides and Application (1 application)		1.90
Preharvest Labor		
Tractor Operation:	2.8 Hrs.	
Hoeing:	5.5 Hrs.	
Irrigation:	2.4 Hrs.	
Total	10.7 Hrs.	10.33
Harvesting†		17.00
	Total	55.31††

*Includes repairs, fuel, oil, grease, interest and depreciation.

**Water costs include operating costs only (fuel, oil and repairs). They represent average costs for plants using natural gas in the area where castor beans are grown.

†Usual custom operations are 85 cents per hundred weight.

††Represents returns to land, management and overhead.

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