

JOJOBA (*Simmondsia chinensis*) —
**A PROMISING INDUSTRIAL PLANT
FOR
INDIAN ARID ZONE**

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JOJOBA (SIMMONDSIA CHINENSIS)

I. INTRODUCTION :

Jojoba (pronounced as ho-ho-ba) an exciting new development in economic crops, is a shrub which grows naturally in the Sonora Desert in the U.S. (California and Arizona) and in Mexico (Sonora and Baja California) The seeds from this thick foliage shrub is about 43 per cent liquid wax with chemical properties identical in most respects to the oil of the endangered sperm whale. Activities aimed at domestication and cultivating jojoba are being pursued actively in Arizona, California, Sonora and Baja California in Mexico, and Israel. Attempts at cultivating jojoba are under way in Saudi Arabia, Ghana, Iran, Egypt and undoubtedly in many other countries.

II. ECONOMIC VALUE :

Jojoba seed yields a liquid wax which requires little or no refining for use as a lubricant. Seed oil content is approximately 50 per cent and is a possible substitute for sperm whale oil, a product derived so far from an endangered species. Its oil has several properties that have made it valuable to industry. It is widely used for many types of lubrication, for the oilness and metallic wetting properties that it imparts and its non-drying characteristics that prevent gumming and tackiness. It is also important as a chemical intermediate since it can be sulfonated, oxidized, sulfurized, sulfur-chlorinated and chlorinated to give products that are used as wetting agents and extreme pressure additives. Jojoba oil possesses several advantageous characteristics over sperm oil : 1) it has no fishy odor, 2) the crude oil contains no stearine and requires little or no treatment for most industrial purpose, 3) it takes up large amount of sulfur, 4) it does not darken on sulfurization, and 5) the highly sulfurized oil is liquid, whereas sperm oil, when highly sulfurized, requires additions of mineral oil in order to remain liquid.

Work is in progress to make candle from jojoba wax. It is presently also used in Mexico for producing hair oil, soap, printing ink and several varieties of shampoo. Besides, jojoba oil has several medicinal uses as well.

The expression of jojoba seed yields a liquid wax which requires little or no refining for use as a lubricant. The wax content of the seed does not decrease with long-term storage, but is remarkably resistant to bacterial degradation. There is a wide variety of potential uses. Because jojoba oil does not become rancid, it might well replace ordinary vegetable oils where rancidity is a problem, such as in foods, cosmetics, and hair oil. The oil is also a source of long-chain alcohols, useful in the preparation of detergents and as lubricants for precision high-temperature machinery.

Hydrogenated jojoba oil is a hard white crystalline wax reportedly almost as hard as carnauba, for which it may be an attractive substitute. It also has potential in the preparation of waxes for floors and automobiles waxing of fruit, impregnation of paper containers, manufacture of carbon paper, candles and many other products.

Table 1 through 3, adapted from products from Jojoba :
A promising new crop for arid lands (National Academy of Sciences, 1975-A), delineates the physical and chemical properties of jojoba oil and wax.

Presently, liquid wax is selling for as much as \$ 8 per pound for use in shampoos and hair oil, and \$ 5.50 per pound for bulk sale. Current projection forecast a per acre yield from mature jojoba plant (7 years old) in U.S.A. and Mexico of 1,760 pounds of seed, which in turn, yield about 750 pounds of liquid wax.

Table 1 : Properties of Jojoba oil^a

Freezing point.	10.6 - 7.0 C
Melting point	6.8 - 7.0 C
Boiling point at 757 mm under N ₂	398 C
Smoke point (AOCS Cc 9a-48) ^b	195 C
Flash point (AOCS Cc 9a-48) ^b	295 C
Fire point (COC)	338 C
Heat of fusion by differential scanning calorimetry	21 Cal/g
Refractive index at 25 C	1.4650
Specific gravity, 25/25 C	0.863
Viscosity	
Rqtovisco (25 C)	
MV-1 rotor in MV cup	35 cup
Plate and cone with Tk-1	33 cp
Brookfield, spindle 1, 25 C	37 cp
Cannon-Fenske, 25 C	50 cp
Cannon-Fenske, 100 C	27 centistokes
Saybolt, 100 C	127 SUS ^c
Saybolt, 210 C	48 SUS ^c
Iodine value	82
Saponification value	92
Acid value	2
Acety value	2
Unsaponifiable matter	51%
Total acids	52%
Iodine value of alcohols	77
Iodine value of acids	76
Average molecular weight of wax esters	606

^a Oil from expeller-pressed jojoba seeds starts to freeze at 10.6 C (51F). It solidifies into a thick paste at 7C. Frozen oil, allowed to warm up, melts at 7C (45F).

^b Smoke and flash points determined according to the official method, Cc 9a-48, of the American Oil Chemists' Society.

^c Saybolt Universal seconds.

Table 2 : Characteristics of Sulfurized Jojoba and Sperm oils.

Test	Sulfurized Jojoba oil	Sulfurized Sperm oil
Sulfur, percent	9.88	9.98
Viscosity, at 37.80	3,518 SUS ^a	1,961 SUS ^a
Viscosity, at 99 C	491 SUS ^a	201 SUS ^a
Specific gravity at 15.6 C	0.9476	0.9613
API at 15.6 C	17.82	15.71
Flash point	250 C	243 C
Fire point	282 C	280 C
Free fatty acids (oleic)	1.55	2.35
Saponification no.	162	195
Tour point	16.1 C	15.6 C
Corrosion, 90/10, 3 h at 100 C	2A	2A
Color, API 10% in 13 color oil	4 1/4	8+

Source : H. Gisser.

^aSaybolt Universal seconds.

Table 3 : Hardness of Hydrogenated Jojoba wax and Several other vegetable waxes

Wax	Hardness ^a
Hydrogenated jojoba oil	1.9
Carnauba wax	2.6
Cane wax	2.1
Beeswax	0.38
Paraffin	0.24

Source : T.K. Miwa

^aBrinell Hardness Number at 25 C, 4.3 kg load for 60 sec. on 10.0 mm diameter steel ball.

III. TEXONOMY OF JOJOBA :

The systematic position of the monotypic genus Simmondsia has been the subject of considerable difference of interpretation. Frequently it has been placed in the family Buxaceae and is properly known as Simmondsia chinensis (Link) Schneider. Its plant has many characteristics, such as ever green foliage, source of fodder as domesticated animals browse on it, drought tolerant and nuts are used as feed by deep and desert peccaries. It is an ever green shrub of approximately 1 to 1.5 m height. Leaves are simple, thick, leathery and coriaceous. Plants are 'dioecious' like papaya and date palm. Female flowers are usually single, inconspicuous, and pale green in colour, while male flowers are small, yellow and occur in clusters. Both types are apetalous and borne in the leaf axis. Normally, only one of the two leaf axile at the node flowers, the opposite bud remaining dormant. Drought conditions can inhibit flowering. Ovary is small tricarpellary, whereas fruit is an acorn like capsule chocolate in colour having one large seed. The seed contains little or no endosperm consisting of embryo and cotyledons enclosed in a thin hard testa.

IV. CULTIVATION OF JOJOBA :

Large scale cultivation of jojoba could provide an alternative source of jojoba seed. High yielding varieties like 'VISTA' could be coupled with optimum irrigation and fertilization treatments to maximise seed production. Proportion of male to female plants, being dioecious, is to be maintained properly for effective fertilization. The development of equipment for efficient machine harvesting would also reduce the loss of seed due to dropping as a result of movement at the time of manual picking.

Among major drawbacks, length of time taken by a jojoba plant to mature (seven to ten years) is most important.

Planting in California have provided useful information regarding responses of jojoba to cultivation. In Israel, jojoba has found an enthusiastic welcome.

Jojoba is drought resistant and prefers rocky well drained soils and thus can become a valuable crop in marginal lands. Also, lands that have previously been irrigated, but have lost their former agricultural potential due to drop in water tables or increases in salinity, are possible areas for jojoba cultivation.

Most successful seed germination requires darkness, warm temperature, and high moisture availability over considerable periods of time, approximately 20 days, before seedling break above ground. Germination success under proper conditions is usually very high. Seedlings that are first established in potted situations and are then transplanted to the field have not always proved successful, probably as a result of root growth patterns of jojoba, since a deep growing radicle with few side roots develops at an early stage. Transplanting success can be increased by root pruning. Seedlings are to be saved from frost damage in early stage.

Since jojoba is a dioecious plant, the sex of plantings is most important point to be kept in mind while undertaking jojoba cultivation. Since no way as yet is known to establish sex of a plant until it flowers, methods must be established for controlling the sex ratio of plants in a plantation. One method is the planting of several seeds at each plant site, with the later elimination of the excess male plants to a level comparable with their role as pollinators.

The only sure way of establishing plants of known sex is by vegetative propagation. This method also allows for the establishment of clones of genetically selected plants of superior quality.

For this reason, much work has been done and it has been found that vegetative reproduction occurs readily from soft wood stem cuttings. This may also have additional advantage as rooting habit of the plant from one of taproot predominance to one with lateral spreading habit will occur making plant more useful for irrigated plantations.

Problems such as spacing of individuals, the placing of males in the population, irrigation practices, and pruning can all affect the productivity. Irrigation of jojoba seemed to have greatly increased the productivity. Method of run-off farming for increased jojoba yield could also be adopted. However, overwatering causes heavy damage to the jojoba plant.

Jojoba's genetic diversity allows the possibility of genetic selection, either through seeds or vegetatively. The 'VISTA' variety has been established from plants grown in California by Coit (1959, 1962). There are obvious possibilities of taking up hybridization and selection work for evolving genetically superior varieties suitable for jojoba cultivation including mechanical harvesting.

One of the major problems of developing jojoba industry based on the harvest of wild plants is the great fluctuation in yield year to year. With cultivated plantations and carefully planned irrigation, the productivity of jojoba plants could be increased and stabilised.

Jojoba appears to be relatively free of disease and insect pests. One moth, a microlepidopteron, appears to be the only serious pest, with larvae showing out the young ovules. This pest seems to be confined so far to areas of over 2,500 ft elevation. One fungus is also known to occur on the leaves, calyxes, and peduncles of jojoba.

V. CURRENT RESEARCH ACTIVITIES :

Research activities are in progress on jojoba in U.S.A., Mexico, Israel and other countries like Japan, Australia, West Germany, Iraq, Iran and Denmark showing interest in its cultivation. Office of Arid Land Studies (OALS) at the University of Arizona, Tucson supports the research on jojoba in U.S.A. and research work at Arizona and California (Deptt. of Plant Sciences, University of California, Riverside) has recently been intensified. OALS also publishes a quarterly newsletter, "JOJOBA HAPPENINGS" to maintain a flow of current information. OALS also arranges for processing and distribution of jojoba seeds liquid wax, hydrogenated wax, and meal for testing their potential usefulness in marketable products.

National Academy of Sciences, U.S.A. has published a volume entitled, "Products from Jojoba : A promising new crop for arid lands" which contain useful information on jojoba.

VI. INTRODUCTION AND PERFORMANCE AT CAZHI, JODHPUR :

Initially a few seeds of Simmondsia chinensis were received from Israel in the year 1965 and seedlings were raised in the nursery at Jodhpur. These seedlings were planted at Jodhpur and Pali farms for trial. Their performance has been rather reasonable at both the places. Out of 12 plants introduced at Jodhpur in 1967, only 2 plants are surviving as on 1977, whereas at Pali Farm, out of 12 plants only 6 plants are surviving.

The plants started flowering since 1974. Flowering takes place in the month of December and continues till March. Being Dioceous, male and female plants are different and effective pollination is necessary for fruit setting. Fruit setting in female plants started since 1976 but yield was less due to improper pollination on account of non-synchrony in flowering of available few female and few male plants. In 1976, about 100 seedlings were

raised in the nursery out of the seeds received through the plant Introduction Division, IARI, New Delhi. In 1977, some more seedlings were transplanted which have survived well under irrigated condition.

As is evident, previous attempts were mainly from the point of view of its introduction, whereas intensive efforts to raise this plant rather on an extensive scale could not be made. Based on the performance of surviving jojoba plants, it can be stated that there appears to be good promise of introducing jojoba plants in the semi-arid zone. A research project on jojoba is likely to be financed shortly by the Department of Science and Technology for undertaking work on Introduction, evaluation and cultivation of jojoba under arid and semi arid conditions of Western Rajasthan.

Recently seeds of jojoba have been received from Arizona and California. In order to undertake intensive testing programme under varying agroclimatic conditions of Western Rajasthan, attempts are presently being made to raise about 5,000 saplings of jojoba in the nursery. 2,000 saplings are already raised in Silviculture nursery and next sowing will now be done in February, 1979. Detailed observations regarding germination, performance of saplings for various morphological attributes are being recorded in the nursery. The germination of jojoba seeds obtained during October, 1978 was about 75 per cent. More attempts are being made to obtain the seed material of jojoba both from the USA and Mexico. Seeds have also been collected from natural habitats in the Sonoran desert in Arizona, USA, personally by Dr R.S. Paroda and attempts will be made to study the genetic variability in this material.

VII. RESEARCH NEEDS :

1. Collection, evaluation and maintenance of genetic variability in jojoba.
2. Studies on cultivation practices
3. Identification of male and female plants and their quick

multiplication through vegetative propagation.

4. Studies on effective pollination and its effect on seed production.
5. Performance tests under varying environmental conditions representing different soil types and eco-systems.
6. Tolerance of jojoba to brackish water and soil salinity/alkalinity.
7. Seed production levels under rainfed and irrigated conditions.
8. Quality analysis of jojoba seed regarding oil content under different conditions.
9. Forage quality analysis in relation to regeneration and production of digestible dry matter.

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