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Review Article

POTENTIAL OF NEOILSEEDS FOR WASTELAND DEVELOPMENT IN ARID ZONE

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A B S T R A C T

India is the fourth largest producer of oilseeds in the world and its production has increased more than five fold since 1950. However, it is still importing vegetable oils to meet the growing demands due to increase in per capita income and increase in standard of living Production and consumption of fats and oils derivatives in non-food use have increased within the last ten years and continue to strengthen as consumers incline towards more natural and environment friendly products and ingredients. Minor oilseeds of tree origin are generally non-edible and can find applications such as in relating to cosmetics, medicine, soap manufacturing, flavoring and perfume industries especially in case of developing countries. Hence to meet the growing demand, emphasis should be given on productivity improvement of oilseeds, besides exploitation of un-tapped potential of the non-conventional and tree-borne oilseeds.

India has an estimated 55.76 million hectares of wastelands and degraded forest and other lands which can be used productively by growing plantations of non-edible oilseeds. This will also help benefiting the large rural population in India by providing employment. Indian arid zone has some of the high oil bearing but lesser known tree species viz. *Salvadora oleoides, S. persica, Pongamia pinnata, Balanites aegyptiaca* , *Citrullus colocynthis* and *Moringa oleifera etc*. They can play an important role in helping the country attain self sufficiency in fats and oils. This paper is an effort to explore the potential of these lesser known oilseed tree species from Indian arid zone in development of wastelands.

INTRODUCTION

Oilseeds, oleaginous fruits and vegetable oils form one of the largest groups of agricultural commodities traded internationally in value terms (after cereals, meat and fishery products), and developing countries play a major and expanding role in this trade. India is one of the largest producers of oilseeds in the world and this sector occupies an important position in the agricultural economy. With an annual average yield of about 32.10 MMT in year 2016-17, India stands fourth as leading oilseeds producing countries, next only to the USA, China and Brazil (Thapa *et al*, 2019). Though the country has made a significant paradigm in the total oilseeds production, the country is not able to pace up with the skyrocketing demand of the oilseed brought about by the booming population growth.

India has optimal conditions for the production of all nine annual oilseeds including seven edible oilseeds, viz. Groundnut, Rapeseed-Mustard, Sunflower, Sesame, Niger, Safflower, and Soybean, and Castor and linseed as non-edible oilseeds.

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Along with these nine annual oilseeds, other minor oil-bearing plants of horticultural and forest origin, including Coconut and Oil palm, and other non-conventional sources like rice bran, cotton seed, corn seed

India has optimal conditions for the production of all nine annual oilseeds including seven edible oilseeds, *viz*. Groundnut, Rapeseed-Mustard, Sunflower, Sesame, Niger, Safflower, Soybean, Castor and linseed as non-edible oilseeds. Along with these nine annual oilseeds, other minor oil-bearing plants of horticultural and forest origin, including coconut and oil palm, and other non-conventional sources like rice bran, cotton seed, corn seed and tobacco seeds also provide substantial quantity of oils (Hegde, 2012). Though the country is gifted with such rich diversity, the cultivation of oilseed crops on poor and marginal soils primarily under rainfed situations has resulted in poor realization of its genetic potential (Singh *et al*, 2014). Because of which, though it covers 20.8% of global area of oilseed crops, the country produces only around 10% of the total production causing disparity between the demand and the supply of these oils that has to be met via imports annually (Directorate of Economics and Statistics,2007-08). Booming populations with higher income is likely to further increase the domestic consumption of edible oils. The annual demand is increasing at the rate of 6% with production increasing with mere 2% per annum (Jha *et al*, 2012).

Thus, there is an urgent need to step up oilseeds production on a sustainable basis. With limited chances of area expansion and with emphasis on increasing production, it is essential to exploit the un-tapped potential of the non-conventional and tree-borne oilseeds from the forests. Primary source are producing 7.31 million tonnes of oils (2016-17) In addition to nine oilseeds, 3.45 million tonnes of vegetable oil is being harnessed from secondary sources like cottonseed, rice bran, coconut, Tree Borne Oilseeds (TBOs) and Oil palm during 2016-17. The Contribution of TBOs in vegetable oil is about 1.50 lakh tones whereas consumption is 0.62% only. A large proportion of oils from secondary sources is lying unexploited in the country (NMOOP, 2018).

Table 1 Annual Production of Non-edible Oil Seeds in India (Arora & Kumar, 2015)

Species	Production (MT)	Oil Yield (Percentage)
Kusum	80	34
Pilu	50	33
Pisa	NA	NA
Karanj	200	27-39
Neem	500	30
Sal	100	200
Mahua	25	17
Thumba	100	21
Ratanjot		30-40

Indian Arid Zone

The arid zone of India covers about 12% of the geographical area and occupies over 38.7 mha, out of which, 31.8 mha is under hot arid region. The hot desert is spread in states of Rajasthan (61%), Gujarat (20%), Punjab (5%) and Haryana (4%), and Andhra Pradesh (7 %) (Challa, 2004). The hot arid eco-system is characterized by low and erratic rainfall, extreme temperatures, very high wind velocities, low humidity and frequent droughts. Low productivity is associated with inadequate length of growing period. It also experiences hot summer and cold winter, annual precipitation ranging between 200 to 500 mm and potential evapotranspiration exceeding 1800 mm, as most of the year is dry with severe drought. The area represents aridic soil moisture regime and hyperthermic soil temperature regime. The eco-system is blessed with an abundance of solar radiation, land and soils capable of responding to management, well adapted grasses, tress and annual crops,. The underground water is deep and saline.

Arid ecosystem is stress agro-ecosystem. The constraints associated with the characteristics of ecosystem and the climatic parameters restrict sustainable productivity, unfavorable growth environment, limited choice of crop and cultivars, particularly in water deficit environs and aberrant weather conditions, low cropping intensity and low and unstable productivity. The constraints in arid ecosystem are limitations imposed by weather, high biotic pressure and soil and water loss due to erosion. Hence land degradation is frequently a serious problem (Challa, 2004).

The states of Rajasthan and Gujarat have large areas of uncultivated wastelands and they offer good scope for development. Wasteland is described as `degraded land which can be brought under vegetative cover with reasonable effort, and which is currently under-utilized and land which is deteriorating for lack of appropriate water and soil management or on account of natural causes'. The Wastelands Atlas 2019 has estimated the spatial extent of wastelands for entire country to the tune of 55.76 million hectares or 16.96 per cent of geographical area of the country i.e. 328.72 million hectares for the year 2015-16. The very high percentage of area under wasteland in the desertic state of Rajasthan (23.04 %) is due to sandy area and in Gujarat (11.09 %) due to Toral wastelands and land with/without scrub (Table 2).

Table 2 State-wise Wastelands of India (area in sq. kms)

S.No.	State	No. of districts covered	Total Geog. area of districts covered	Total WL area in districts covered	% to total Geog. area
1.	Rajasthan	32	342239.00	78851.33	23.04
2.	Gujarat	25	196024.00	21740.39	11.09

Source: Wastelands Atlas of India, 2019.

Utilization of wastelands

Of India's total geographical area (328.7 Mha), 304.9 Mha comprise the reporting area with 264.5 Mha being used for agriculture, forestry, pasture and other biomass production. According to the National Bureau of Soil Survey and Land Use Planning, 2005, ~146.8 Mha is degraded.

Assuming we plant oilseeds bearing trees at the rate of 400 trees ha^{-1} under managed conditions, considering the poor nutritional status of these soils and if Pilu is taken as a representative source of forest based oilseeds from arid areas the average yield of fruits from mature trees will be 4 tonnes ha^{-1} or 1200 kg ha^{-1} of seeds (10 kg fruits/tree or 3 kg seeds/tree). Thus, the approximate amount of oil that can be obtained from one hectare of wasteland is 400 kg. Even if one-fourth of the wasteland can be utilized then the approximate amount of oil that can be obtained is about 10 million tonnes from Rajasthan & 5 million tonnes from Gujarat. Thus, the potential is enormous (Bhattacharyya, 2015). In Rajasthan and Gujarat tribal people collect seeds from naturally occuring plants and selling it to co-operatives or Forest development corporation at the rate of Rs 4 to 5 per kg. (CSMCRI-2003) .

Oilseeds from Arid Zone

The forest resources of the arid zone are rather limited, but surprisingly there are a large number of unexploited, under-utilized and lesser-known plant species of potential economic value for rural development. Potential of some less known oilseed tree species from Indian arid zone is discussed below:

Salvadora species **(Salvadoraceae)**

It is a small genus of evergreen trees or shrubs. Two species of *Salvadora i.e., S. persica* and *S. oleoides* are available in India. The genus, *Salvadora* was placed under the group, facultative halophytes, because of its occurrence in both non-saline to very highly saline habitats.

Salvadora oleoides

It is popularly known as `mitha jal' or `Pilu' and is a large shrub or small evergreen tree found growing wild in arid and sandy areas of Rajasthan, Gujarat and Uttar Pradesh. In Rajasthan it is found in Jodhpur, Barmer and Jaisalmer. It seldom exceeds 3.66 m in height and has a short, twisted or bent trunk. It has numerous stiff, divergent and whitish branches, the lower ones drooping and often touching the ground. Leaves are ashy green or glaucous, coriaceous and somewhat fleshy when mature, Flowering occurs during January to March in western parts of India. Flowers are small, greenish yellow or greenish white produced in clusters. Fruiting is in the month of May (Bhandari, 1990). The fruits are greenish yellow; red brown when ripe, globose drupe. Fruits are plucked or felled by shaking the trees vigorously. The yield of fresh fruits per tree from mature trees is 10-15 kg or 2-3 kg dried fruit (Dwivedi,1993). Seeds form 44-46% of the whole fruit and estimated potential is 47000 MT from collection centres of Rajasthan, Gujarat and Punjab. About 40 % kernel yield is obtained on decortication. Oil content is 19-21 % in the fruit and 34% in the seed (CSIR, 1988a).

Pilu fat is used upto 20 % in soap to replace coconut oil. It is rich in lauric and myrsitic acid (Table 3) and is also used as a resistant in the dyeing industry. The bruised root-bark has a vesicant effect and the sweet fruit, which is eaten in Northern India, irritates the mouth producing tingling and ulceration (Behl *et al*, 1966). The seeds contain a thioglucoside, glucotropaeolin, related to mustard oils of Cruciferae (Kjaer, 1963).

Salvadora persica

The plant popularly called as `Khara jal'or the `Toothbrush tree' is widely distributed in India in Rajasthan, Gujarat, Haryana, Punjab and to some extent in Andhra Pradesh, Karnataka and Tamil Nadu. It is a small/medium-sized tree with twisted/crooked and glaucous trunk, seldom with more than one foot in diameter and drooping or spreading branches. The branches are pale green, root bark is light brown and the inner surfaces are white and leaves are green. Flowers are small, greenish yellow and bisexual. There are three types of berries/fruits, viz. pink, white and dark. Of the three pink berries has higher oil content (38-40%). Seeds are of 1-4 mm in diameter. The yield of kernels is 60 % in the dried seed, 49 % in the dried fruit and oil content is 40-43 %. The oil yield in expeller is 39 % from the kernel. Seed oil is rich in lauric acid (Table 3) for replacement of coconut oil in soap & detergent industries (FAO, 1986). Lodha, 2004, has nutritionally evaluated the seeds.

It is a drought-tolerant tree that grows very well on coastal sand dunes, marginal to high saline wastelands with or without water logging, ravines and saline/ alkaline dry zones. The plants can yield 3.5 tonnes seeds/ha/year (NEDFCL, 2002). In the process of development of agrotechnology the yield of seeds is also reported to be 1200-1500 kg seeds/ha/year (Technology Flash from India, 1995). Hence variable yield figures are reported. Harvesting need be done when 50 % of the berries turn to pale yellow. The potential of pilu seed in the Rajasthan, Gujarat and UP is 12,500, 31,488 and 18 tonnes (Dwivedi,1993; Gupta & Guleria,1982). The seed and oil yield recorded at different salinity levels over four years indicated that there is an increase in yield from the first year to the fourth year at all the salinity levels. The oil content was found to be the highest 2.6% at low salinity of 55-65 dSm-1. This indicates that seed oil content did not vary much with increase in salinity. Though the seed yield declined by about 40-47 % at higher salinity, when compared to low salinity this species could yield about 1.5 Mgha-1 seeds on highly saline soils (Rao *et al*, 2004).

The species is having immense medicinal value with manifold uses. The plant is used for oral hygeine & medicine. Several agents occurring in the wood have been suggested as aids to prevention of dental caries (FAO, 1988) On a hot, sunny day the plant gives off an acrid odour. The leaves taste like mustard (Brassica). A paste of the powdered root is used like a "mustard plaster" for an irritant effect and can produce vesication (Watt & Breyer-Brandwijk, 1962, Behl *et al*, 1966).

***Pongamia pinnata* (Fabaceae)**

Karanj (*Pongammia pinnata*), a leguminous tree has many traditional uses and is one of the important species. This tree is known by many names viz., Indian Beech, Pongam, Honge, Ponge and Karanj, etc. and mostly used for landscaping purposes as a wind break or for shade due to the large canopy and showy fragrant flowers. The genus has only a single species. It is a medium sized tree, reaching a height of 8 m (NFT Highlights, 1997). Trees reach an adult height in 4 or 5 years, bearing fruits at the age of 4–7 years. The natural distribution of *Pongamia* is along coasts and river banks in India. The tree is hardy, reasonably drought resistant and tolerant to salinity. The trunk is generally short with thick branches spreading into a dense hemispherical crown of dark green leaves. The bark is thin gray to grayish- brown, and yellow on the inside. The alternate, compound pinnate leaves consist of 5 or 7 leaflets which are arranged in 2 or 3 pairs, and a single terminal leaflet. Leaflets are 5-10 cm long, 4-6 cm wide, and pointed at the tip. Flowers, borne on racemes, are pink, light purple, or white. The tree bears green pods which after some 10 months change to a tan colour. The pods are flat to elliptic, 5-7 cm long and contain 1 or 2 kidney shaped brownish red seeds which are 10-20 cm long and fig oblong (GOI, 1983).

The composition of typical air dried kernels is: moisture 19 %, oil 27.5 %, protein 17.4 % (FAO, 1992). The yield of kernels per tree is reported between 8 and 24 kg. A single tree is said to yield 9–90 kg seed per tree, indicating a yield potential of 900-9000 kg seed/ha, 25 % of which might be rendered as oil (assuming 100 trees/ha) (Duke, 1998). One hectare of honge plantation could yield 10 tones of seeds which can yield a gross revenue of Rs 40,000 (which is good revenue for dry land), provided high yielding plants are selected (Shrinivasa 2001) . It is suggested planting seedlings a hundred times more densely than is normally required. Though the yield per plant may be less in the earlier years, this is compensated for by the higher density.

The most common method of harvesting involves climbing the tree and beating off the pods with sticks. The dried pods are struck with hammers and sticks to open them after which the seeds are winnowed out. A thick, dark yellow-orange to brown oil with a disagreeable odour and difficult to refine is extracted from seeds. The oil content varies from 27-39 %. The oil contains toxic flavonoids including 1.25 % karanjin and 0.85 % pongamol .Yields of 25 % of volume are possible using a mechanical expeller. However, village crushers average a yield of 20 % (ICFRE, 2011).

The oil has a bitter taste and a disagreeable aroma, thus it is not considered edible. In India, the oil is used as a fuel for cooking and lamps, as a lubricant, water-paint binder, pesticide, and in soap making and tanning industries (Vijayalaxmi *et al,* 1999). *Pongamia* oil is rich in oleic and linoleic acids. Major fatty acid composition of oil is given in Table 3. The linoleic acid makes the soaps great conditioners. Olive oil is useful for better emollient and moisturizing qualities. Soap made from crude oil tends to darken due to a component, Isolonchocarpin, which gives a wine red colour in the presence of alkali. The oil is known to have value in folk medicine for the treatment of rheumatism, as well as human and animal skin diseases. It is effective in enhancing the pigmentation of skin affected by leucoderma or scabies (ICFRE, 2011). In rural areas the leaves are used to prevent infestation of grains. The cake after oil extraction may be used as a manure. The presence of a hypotensive principle and a substance producing uterine contraction has been reported (FAO, 1992). In the 1970's India was producing 4000-6500 tonnes of oil per annum.

The potential of pongamia seed in the Rajasthan and Gujarat is 350 and 3,121 tonnes (Dwivedi, 1993). Total actual collection is of 25,000 tonnes only (Table 2). Wherever it is grown, the wood (calorific value 4,600 kcal/kg) is burned for cooking fuel. The thick oil from the seeds is used for illumination, as a kerosene substitute, and lubrication. It would seem that with upgraded germplasm one could target for 2 MT oil and 5 MT firewood per hectare per year on a renewable basis (CSIR, 1988b). This oil is rapidly gaining popularity as an important source of biofuel. A total of 143 accessions were collected from diverse agro-climatic zones of states like Uttar Pradesh, Madhya Pradesh, Rajsathan and Haryana and evaluated for growth oil & yield (Dhyani *et al*,2015).

Balanites aegyptiaca (Zygophyllaceae)

This is a genus of two or three species viz. *Balanites roxburghii* , *B. aegyptiaca* (identical with *Balanites roxburghii*) and *B. triflora*. *Balanites aegyptiaca is m*ost commonly called as `Hingota'. It is a small multibranched, spiny tree up to l0-20 m tall very common in open sandy plains. It is common in wastelands, fringes of forests etc. sometimes planted along the roads. It is widely distributed in Rajasthan, Gujarat and Uttar Pradesh. In Rajasthan it is found in Ajmer, Bikaner, Jaipur, Banswara, Churu, Pali, Sirohi, Mount Abu. Trunk is short and often branching from near the base. Bark is dark brown to grey, deeply fissured. Crown is spherical, in one or several distinct masses. Branches are armed with stout yellow or green thorns up to 8 cm long. Leaves with two separate leaflets; leaflets obovate, asymmetric, 2.5-6 cm long, bright green, leathery, with fine hairs when young. Flowers in fascicles in the leaf axils, fragrant, yellowish-green. The deep rooted *Balanites* tree lives for more than 100 years (Bhandari, 1990).

The flowering occurs in December to March and fruiting time is from March to July. Young fruits are green and tormentose, turning yellow and glabrous when mature. The brown outer skin consists of a sticky pulp within which lies the oil bearing seed or nut. Analysis has shown that the fruit typically consists of 21.8 % outer skin, 30.7 % pulp, 36.7 % shell and 10.8 % kernel on a dry basis (FAO, 1992). Pulp is bitter-sweet and edible. The fruits are collected by spreading a tarpaulin under the tree and shaking the branches until the fruits are released. Climbing is inconvenient because of the long branch thorns. A mature tree may yield up to 10,000 fruits per year which equals about 100-150 kg, or 55-80 kg of seed. Usually a smaller amount is harvestable due to the prolonged fruiting season and predation. Seeds may also be obtained from fruits that are being processed for other purposes. Seed is a pyrene (stone) and is 1.5-3 cm long, light brown, fibrous and extremely hard. It makes up 50-60% of the fruit. There are 500-1500 dry, clean seeds per kg (Hall & Walker, 1991).

Shelling has been noted as a problem, one solution that has been used to improve efficiency is to simply saw the nuts in half to release the kernel. Every ton of whole fruit processed yields half a ton of hard woody shell which is highly combustible and produces a high quality charcoal. The kernel yields a highly stable, golden yellow edible oil (40-46 %) (Abdel-Rahim,1986). The fatty acid composition is given in Table 4. The oil can be used for production of soaps. It possess antibacterial and antifungal properties. The oil extraction process produces an oilcake suitable for animal feed. It has a high protein (36.8 %) and low fibre content (5.9 %) (El Khindar, 1983).

The *Balanites* tree is used locally for many products: the fruit for sweets and alcoholic beverages, and the kernels for cooking oil and medicines. The stem of the tree contains steroidal saponins which have been shown to have an insect antifeedant and molluscicide properties (Jain, 1987). The fruits and the defatted seeds are a source of diosgenin. *Balanites* is particularly suited to arid regions. Assuming that if there are a million trees growing in the desert which could produce up to 100000 tonnes of whole fruit annually and that some 4000 tonnes of oil could be extracted.

In a paper by Bambara *et al*, 2018, an optimization model for a wild biomass supply chain was developed to identify the optimal organization of the supply network that minimizes the cost of supplying the feedstock. The results show that more than 35% of the cost price of *B. aegyptiaca* seed is accounted for by transport costs. Pre-processing, handling, and storage costs account for about 50% of the cost of the seeds.

Moringa oleifera (Moringaceae)

Two species are found in India viz. *Moringa oleifera* and *Moringa concanensis*. *Moringa oleifera* is known as sahjan, drumstick or 'horseradish' tree. It ranges in height from 5 to 12 m with an open, umbrella-shaped crown, straight trunk and corky, whitish bark and the tree produces a tuberous tap root. A native of northern India, *M.oleifera* is now grown widely throughout the tropics. The evergreen or deciduous foliage (depending on climate) has leaflets 1 to 2 cm in diameter; the flowers are white or cream coloured. The tree grows rapidly from seeds or cuttings, flowering and fruiting have been observed within 12 months of planting out. The fruit is an angled pod, 6 to 12 inches in length, which contains about 20 small, angled seeds. Fully mature, dried seeds are round or triangular, the kernel being surrounded by a lightly wooded shell with three papery rings (Ramachandran *et al*,1980).

In areas where the climate permits, e.g. southern India, two harvests of pods are possible in a single year. Within three years a tree will yield 400-600 pods annually and a mature tree can produce up to 1,600 pods. Recent estimates suggest that, for a spacing of 3m, a likely annual seed yield is 3 to 5 tonnes per hectare (Morton, 1991). About 5000 seeds are found to be present in a kilogram (FAO, 1988). The seeds contain 25 to 35 percent of non-drying oil. As the Table 3 shows, the fatty acid composition is considered to be similar to that for olive oil (Dahot & Memon, 1985).

If *Moringa oleifera* produces 3000 kg seed from 1 ha then it can produce 1200 kg edible oil, as compared to soybean which produce 350–400 kg oil from 1 ha (Mohammed *et al*, 2003). India has adopted a wise strategy and started the commercial production of MOO, currently, 1.3 M. Ton of edible oil is annually extracted from the seeds of *Moringa oleifera*, with 380 KM^2 area of production (Rajangam *et al*, 2014). The cost of production of oil from *Moringa oleifera* is low as compared to other sources of edible oils. In addition to low cost and higher oil content, oil has better functional properties over soybean, sunflower, canola, corn oils, they need partial hydrogenation for improved functional properties, whereas, MOO does not require partial hydrogenation. It can also be converted into olein and stearin fractions, which only have better functional properties but can also serve as superior alternates of partially hydrogenated fats. Further it contains about 5–6% behenic acid, which act as crystallizing agent (Abdulkarim *et al*, 2007). In subcontinent, crystallized vanaspati is preferred over pasty stuff and application of MOO in vanaspati can improve its graininess and crystallization behaviour. The oil is high in oleic acid and thus of high market value for cooking, soap manufacture, in cosmetic base and lamps. *M. oleifera* seed oil has good oxidative stability (Nadeem & Imran, 2016).

Oil production potential of *Moringa oleifera* was assessed in arid climate of Chaco South Africa, on average basis; it produced 481.25 Kg edible oil from one acre, desert conditions did not have significant effect on the seed production and oil content (Ayerza, 2011).Commercial oilseeds require good quality soil with plenty of water, adequate fertilization and other expensive agronomic practices, whereas, Moringa tree can be grown in poor quality sandy, salt affected soils and it can resist long spells of drought with no effect on oil yield. The results of another investigation conducted in Argentina disclosed that *Moringa oleifera* trees produced 595 kg oil/acre in drought conditions (Ayerza, 2012).

The press cake remaining after oil extraction contains the active components effecting coagulation. It may be utilized as a fertilizer. Its use as a potential animal feed has not been recommended as it contains an alkaloid and a saponin (CSIR, 1988; Makkar and Becker, 1999). *M. oleifera* leaves can be harvested and dried during dry seasons when there are no other fresh vegetables available. The immature green pods are consumed by Asian populations world-wide and canned pods are exported from India (Anhwange *et al*, 2004).

Citrullus colocynthis (Cucurbitaceae)

Two species are found in India viz. *Citrullus colocynthis* & *Citrullus vulgaris*. *Citrullus colocynthis* is a non hardy, herbaceous perennial vine, branched from the base. It is commonly called as Tumba ,colocynth, wild-gourd or bitter-apple. The colocynth plant is a native of warm, arid and sandy soils. Originally from Tropical Asia and Africa, it is now widely distributed in the western arid zone of Rajasthan and occurs wild in Jodhpur, Barmer Jaiselmer. It has a large, fleshy perennial root, which sends out slender, tough, angular, scabrid vine-like stems. These usually lie on the ground for want of something to climb over, but which, if opportunity present, climb over shrubs and herbs by means of axiliary branching tendrils. The leaves are rough, 5–10 cm in length, deeply 3–7 lobed; The flowers are solitary yellow, long-peduncled, solitary in the axils of the leaves. distinguished by a globose, hairy, inferior ovary (Feinbrun–Dothan 1978). The fruit is globular, smooth, with a hard but thin rind, something like a gourd. It is filled with a soft, white pulp, in which are imbedded numerous seed. Each plant produces 15–30 round fruits, about 7–10 cm in diameter, green with undulate yellow stripes, becoming yellow all over when dry. Seeds are small (6 mm in length), smooth and brownish when ripe. The kernels form about one-third of the whole seed, which were found to contain 16.94 per cent of fatty oil, 5.93 per cent of albumen, 2.48-2.7 per cent ash, and 7.17 per cent of water. The proportion between pulp and seed varies according to different authors, from 23 to 33 per cent of pulp and 67 to 77 per cent of seed (Yadav and Singh, 1992, Lloyd & Cincinnati, 2005).

The number of fruits harvested per plot (10 m) varied from 112 to 129, Fruit size was determined by its diameter and varied from 5.7 cm to 6.3 cm. Fruits of *C. colocynthis* contain a large number of seeds. Numbers varied between 291 and 404 seeds per fruit; 1000-seed weight was about 40-44 g. Seed yield was 2.1 kg/10 m^2 to 1.5 kg/10 m^2 (Yaniv *et al*,1999).

Oil content in seeds varied from 17 to 19.5%. Based on this data and seed yield, oil yield of 250 to 400 L/ha was calculated. The fatty acid composition of the seed oil of *C. colocynthis* is very similar to that of safflower oil (Yaniv *et al*. 1996). The fatty acid composition is given in table 3 (Oresanya *et al*, 2000). The two major fatty acids in seed oil of *C. colocynthis* are C18:1, oleic (11.7–15%) and C18:2 linoleic (66–70%). The total yield of unsaturated fatty acids varied from 209 to 327 L/ha. This oil contains only traces of C18:3 linolenic acid and thus could provide a good source of edible oil **(** Rao, 1994; Al-Khalifa, 1996).

Thus, this arid zone plant has a great potential and occurs in abundance in Rajasthan (Paroda, 1979). The dried pulp of unripe but full grown fruit freed from rind constitutes the drug 'Colosynth'. The roots have purgative properties and are used in jaundice, rheumatism and urinary diseases. The seed has a brownish yellow oil which contains an alkaloid, a glucoside and a saponin (Anon, 1960).

Most of the accessions of the desert gourd were also found to be higher yielding than Jatropha – a nonedible biodiesel crop with the reported oil yields of about 1.5 to 2 tons ha-1 (Sujatha *et al*., 2008). Jatropha yields are however, highly dependent on climate and soil conditions (Tikkoo *et al*, 2013). In current studies, the maximum oil yields obtained in desert gourd were similar to the yield reported in *Calophyllum inophyllum* (4.68 tons ha-1) but lower than that of palm oil (5.95 tons ha-1) (Atabani *et al*, 2012). Nevertheless, compared to other biodiesel feedstock crops, desert gourd is more likely to be tolerance to marginal growing conditions with lower water requirements because of its natural adaptation to desert environments (Menon & Sood, 2016).

T**able 3** Some Physico-chemical constants & Fatty acid composition (%) of forest based Neoilseeds from arid zone (CSIR, 1988 a & b, Suri & Mathur,1988)

	Pongamia pinnata	***Salvadora oleoides***	***Salvadora persica***	***Balanites aegyptiaca***	***Moringa oleifera***	***Citrullus colocynthis***
Acid value	6.3	0.71	2.2	0.6	3.5	0.7
Saponification value	181.5	233	243	195.2	182.2	213.8
Iodine value	89.1	3.6	6.1	88.3	64.2	109
Fatty Acids						
Capric	-	0.77	1.0	-	-	-
Lauric	-	35.6	19.6	-	-	-
Myrsitic	-	50.75	54.5	-	0.1	-
Palmitic	3.7-7.9	-	19.5	24.2	5.0	10.3
Palmitoleic	-	-	-	-	1.4	-
Stearic	2.4-8.9	-	-	5.5	5.2	14.7
Arachidic	2.2-4.7	-	-	-	3.7	-
Behenic	4.2-5.3	-	-	-	8.1	-
Lignoceric	1.1-3.5	-	-	-	0.4	-

Oleic	44.5-71.3	8.28	5.4	50.5	70.7	15.5
Linoleic	10.8-18.3	0.06	-	19.9	1.5	56.9
Eicosenoic	9.5-12.4	-	-	-	2.3	2.5(others)

Pongamia pinnata has maximum acid value which shows that this oil rancidifies early as compared to other oils (Table 3). *Citrullus colocynthis* and *Salvadora oleoides* have minimum acid values. The saponification value of *Salvadora oleoides* and *S. persica* is the maximum so among the above species they are the most suitable oils for soap making. Iodine value of these oils indicates that all of them are non-drying oils excepting *Citrullus colocynthis* which is a semi-dryng oil. Thus all of these with suitable refining techniques can be made use for cooking purposes. The fatty acid composition shows that *Citrullus colocynthis* oil has maximum amount of linoleic acid thus has high therapeutic importance. The oleic acid is present in higher amounts in *Moringa oleifera , Balanites aegyptiaca and Pongamia pinnata* oils. These oils can suitably be used in manufacture of soaps & detergents, lubricants, cosmetics and as emulsifying agents. *Citrullus colocynthis* oil has highest stearic acid content and thus is the most suited among the rest for use in soaps, lubricants, toothpastes, rubber industry, food packaging etc.

Benefits of lesser known oilseeds

Thus, systematic propagation and processing of these lesser known oilseeds of tree origin have many benefits of national and international importance. Some of these are discussed below:

Providing Rural Employment

The processing of the non-edible oilseeds is done in simple oil mills, oil expellers and solvent extractors which mostly already exist at District levels. Many of them do not have sufficient work at present due to liberalization of imports of edible oil. By increasing the availability of oilseeds of tree origin, which can be processed in the same machines, rural employment can be increased

Women's involvement with increased Rural Income

Development of non-edible oils from trees is completely decentralized and is largely located in rural areas. It would increase the income of rural populations as these trees can be grown on land, both common and private. Collection of these oilseeds is mainly done by rural women/ Women's Self Help Groups in an organized manner, thus helping them to a significant extent (Shrinivasa, 2003).

Utilizing Organic Manure

As synthetic fertilizers are costly and environmentally harmful, the need for natural and organic fertilizer is obvious. After extracting the oil, as much as sixty percent of the non-edible oilseeds is in cake form and can be used as organic fertilizer by the farmers for enriching the soil for farming. As the oil extraction facilities require only small-scale investment and are spread in rural areas, the farmers will greatly benefit as they can fetch them without long-distance transport cost.

Biofuels for Fuel Security

India's known crude oil reserve is estimated to last only for about 21 years. Non-renewable fossil fuels are getting reduced at a faster rate than ever before pushing the resources at the brink of exhaustion. India was the third largest crude oil importer in the world in 2018 (BP Statistical Review of World Energy 2019). The country spent an estimated Rs. 8.81 lakh crore (US$120 billion) to import 228.6 million tonnes of crude oil in 2018–19. Hence, the oil import bill has serious consequences on the Indian economy. With insufficient oil resources, India cannot rely on imported oil, which will seriously affect its economic development and sovereignty in international political relations. Therefore, as a matter of necessity and national self-reliance, India has to strive to achieve self-sufficiency in fuel availability. This can be achieved by bio-fuels obtained from non-edible oilseeds. Substitution of bio-fuel processed from non-edible oilseeds such as *Pongamia pinnata, Jatropha curcas* etc. for oil will therefore have a positive effect on reducing imports.

A National Biodiesel Mission, 2009 was launched by the Planning Commission to cover 2.5 million ha area in the country, to meet 5 % replacement of the diesel requirement of the country. Government of India had fixed the target to replace 20 % petrodiesel with biodiesel up to 2011-12 by producing 13.38 million tons of biodiesel annually through plantations of Jatropha alone in 11.19 million ha. However, the Department of Agriculture and Co-operation, Ministry of Agriculture, has formulated the Mini Mission III to promote the oil seeds in addition to TBOs for biofuel. The aim of Mini Mission III of National Mission on Oil Seeds and Oil Palm (NMOOP) from the current year is to promote 11 tree borne oilseeds (Simarouba, Neem, Jojoba, Karanja, Mahua, Wild Apricot, Jatropha, Kokum, Tung & Olive) (Dhyani *et al*,2015).

Products from Renewable Resources

Market demand for products and derivatives based on naturally renewable resources is increasing continuously, also in the chemical industry. Both ecological soundness and product performance are of overriding importance. Being sourced from trees already existing and to be further propagated, oleochemicals from vegetable oils find great demand in the market.

CONCLUSIONS

At present, the tree borne oilseeds (TBO's) contribute an insignificant portion of vegetable oil production in the country mainly due to lack of improved varieties, elite planting material and agronomic practices. Promoting TBOs has many benefits to the country and the environment, in terms of additional supplies of vegetable oils, employment to needy population, ecofriendly system, foreign exchange earnings, diesel substitution and pollution reduction.

There are a number of oilseeds tree species that are known to have good potential for seed production. The likely benefits will be higher than the costs. Most tree species which provide oilseeds can be grown on comparatively less fertile soils, generate amounts of tangible benefits and generate a number of intangible products besides seeds. Thus, where efforts to enhance the production of cultivated oilseeds would continue, simultaneous efforts to harness the potential for tree based oilseeds will go a long way towards relieving the pressure on agricultural lands, substantial improvements in the rural economy and better utilization of the installed oil crushing capacity in the country.

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