

# Niger Seed (*Guizotia Abyssinica*) as a Source of Biodiesel in India

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**Abstract:** The need of producing alternate fuels is the fast depletion of conventional petroleum fossil fuel reserves and concerns of economic and environmental protection from the pollution. The use of biodiesel from the vegetable oils as an alternate fuel is a worldwide attraction. The present study is to consider the niger seed oil is a potential agricultural feedstock as alternate source of fuel for transportation and other energy requirements. Niger seed is an oilseed crop produced principally in Ethiopia, India, Myanmar and Nepal and even it is tried in U.S.A and European countries. It contains 85% poly unsaturated fatty acid mostly comprising of linoleic and oleic acid. Its seed contains 37 to 43% oil. The niger oil is used in foods, for paint, soap making, perfumes, illumination and also as fuel for running water lift pump sets in rural and tribal areas. The aim of this paper is to study the importance and growth of niger in India and compare the physicochemical properties of Soybean ME and Sunflower ME extensively used as alternate fuel in US and in some other countries.

**Keywords -** Agricultural feedstock; Fatty acid; methyl ester;

## I. INTRODUCTION

Conventional petroleum fossil fuels play a vital role in rapid depletion of energy sources along with increasing demand and also major sources of environmental pollutants. Today's energy demand in India is being met mainly with fossil petroleum fuels. In order to enhance the energy, environmental protection, greenhouse effect reduction and economic stability of the country, is the need to produce alternate fuels derived from local vegetable feedstock sources. As India is an agricultural country, there is a wide scope for the production of vegetable oils (both edible and non-edible) from different oil seeds.

Fuels derived from renewable non- conventional vegetable resources for use in diesel engines are known as bio-diesel. It is mono alkyl esters of long chain fatty acids. Biodiesel is typically produced through the reaction of a vegetable oil or animal fat with methanol or ethanol in the presence of a catalyst to yield glycerin and respective esters and widely termed as transesterification process. The biodiesel may be produced from different vegetable edible and non-edible sources like *Jatropha*, *Pongamia*, *Neem*, *Mahua*, *castor*, *linseed*, *Kusum*, *coconut*, *palm*, *sunflower*, *mustered*, *soybean*, *safflower*, *sun flower*, *niger*, etc.

India is the chief niger producing country in the world, with an area of 480,000 ha (ICAR 1997). In India the niger is considered as a nontraditional edible oil crop and about 75 percent of the seeds produced are used for oil extraction while the rest is exported for bird feed. The byproduct press-cake after the oil extraction contains 31 to 40 percent of protein and is used as cattle feed. Niger oil has been used as an alternative to diesel by remote communities in India for many years. The present work is focused on the study of growth, availability and utilization of niger seed/oils. Also the study of physical and chemical properties of oil/methyl esters of niger seeds are discussed.

## II. LITERATURE REVIEW

The review of literature revealed the potential of non-traditional edible oil like niger seed oil as biodiesel fuel instead of petroleum diesel used in CI engines with or without small modifications. But research work on niger seed oil biodiesel was found to be very limited compared to other vegetable oil biodiesel feedstock.

GeethaVaidyanathan et al revealed in their study that a small tribal kinchiligi village of population 75 in odisha state used 450 litres of 100% neat biodiesel in regular pumpsets to lift drinking water over a period of 3 years. The village level production unit produces 10 litres per day using a pedal driven machine. The local harvested niger seeds were used as raw material for the production of biodiesel [1]. Demirbus mentioned in his research paper that the niger seed (*Guizotiaabyssinica*) is one of the potential biodiesel edible oil feedstock [2]. Mohan Kumar et al described the important feature of this crop is that it gives reasonable seed yield even under poor marginal growing conditions and Niger is mainly cultivated for extraction (about 30-50%) of oil which is used for soap making, lighting, lubrication and also used as a biodiesel [3]. Rakeshsarin et al has confirmed the niger oil as a source of potential biodiesel feed stock as per IS 1460 specifications and also mentioned that the niger oil is a non-traditional edible oil which may not come under the food security concern [4].

Gubitz GM et al mentioned in their research paper that Niger seeds (*Guizotia abyssinica*) is cultivated in tropical countries and is quite expensive as it is imported usually from

Ethiopia and India. Also the Niger seed oil has been identified as a potential biodiesel crop because of the presence of 50–60% the oil called biocrude, which can be converted into biodiesel by chemical or lipase mediated esterification [5]. USDN Gain: in its reports mentioned that India annually exports of volume around 1 million tons, including approximately 300,000 tons of minor oilseeds worth of more than \$1 billion high value handpicked select (HPS) oilseeds include peanuts, sesame, niger seed, cottonseed, safflower seed and rapeseed-mustard [6].

### III. GENERAL MORPHOLOGY OF NIGER PLANTS AND SEEDS

Niger (*Guizotia abyssinica* (L.f.) Cass.) is an oilseed crop cultivated for more than 5000 years. It is widely grown in South India and Ethiopia, which are the two major countries producing Niger [7]. The Common names of Niger are nigerseed, noug, guizotiaoléifère, ramtil, nigersaat, verbesina da Índia, abisin, negrilla, ramtilla.

There are six species of *Guizotia* with *G. abyssinica* being the only cultivated species (Baagø, 1974). Niger seed belongs to the same botanical family as sunflower and safflower (*Compositae*). The crop grows best on poorly drained, heavy clay soils (Alemaw and Wold, 1995; Francis and Campbell, 2003). Niger is cultivated in both temperate and tropical climates, being considered a temperate-region plant that has adapted to a semi-tropical environment. It prefers moderate temperatures for growth, from about 19°C to 30°C (Quinn and Myers, 2002)

#### A. BOTONICAL DESCRIPTION

Niger is an annual dicotyledonous herb. The root system is well developed, with a central tap-root and its lateral branching. The stem of niger is usually round, smooth to slightly rough, hollow and moderately branched. The fruit is small 3-5 mm in length and 1.5mm in width. There are usually between 15 and 30 mature seeds/head; (fig.2) occasionally more, and a varying number of immature seeds or pops at the centre [8].

It is a dicotyledonous herb, moderately to well branched, growing up to 2 m in height [9]. The first leaf is paired and small and successive leaves are larger. The leaves are arranged on opposite sides of the stem; at the top of the stem leaves are arranged in an alternate fashion. Leaves are 10-20 cm long and 3-5 cm wide (Fig. 1). The leaf margin morphology varies from pointed to smooth and leaf colour varies from light green to dark green, the leaf surface is smooth. The stem of niger is smooth to slightly rough and the plant is usually moderately to well branched. Niger stems are hollow and break easily. The number of branches per plant varies from five to twelve and in very dense plant stands fewer branches are formed. The colour of the stem varies

from dark purple to light green and the stem is about 1.5 cm in diameter at the base. The niger flower is yellow and, rarely, slightly green. The heads are 15-50 mm in diameter with 5-20 mm long ray florets. The plant height of niger is an average of 1.4 m [10].



Fig.1: niger seed plant



Fig. 2: Niger seeds



Fig. 3: Niger leaves & flowers

#### B. Cultivation and Harvesting

Niger seed are broadcast or sown in rows in tropical areas (during June to August for a rainy season crop, and

September to mid-November for a winter season crop in India). Seed may be broadcast at rate of 10 kg/ha or sown in rows 40 to 50 cm apart at rate of 5 kg/ha. One hand-weeding is usually sufficient. Many cultivators do not manure the land. Best yields of seed and straw obtained with a balanced and good selection of fertilizer. In India, when niger is mixed with ragi, rows should be 15–30 cm apart to allow weed control, the land being harrowed 3–4 times before planting. Niger is a good crop for rotation with corn or wheat.

Niger is harvested 3–4.5 months after planting, depending on the region. It should be allowed to stand until flowers have withered. Further delay will cause heavy loss of seed through shedding. Crop can be harvested by hand or machine. Threshing is mostly done by hand in India. Seeds are easily separated then they are cleaned of all earth and weed seed by winnowing and sieving.

### C. Geographical Distribution in India

India is the most important country accounting for more than 50% of world niger area and production. The oil seed production is mostly saturated in southern and central districts. In India, niger is grown on an area of 0.52 million ha mainly during kharif. However, in Orissa it is a rabi crop. Madhya Pradesh, Maharashtra and Orissa contribute more than 80% of area and production. Other states where niger is grown are Andhra Pradesh, Bihar, Karnataka and West Bengal as mentioned in the table 1 [8].

Table I. Area, production and Productivity of Niger in different states of India (2003-04).

State	Area (hectare)	Production (tonnes)	Yield (kg/hectare)
Andhra Pradesh	17.0	7.0	412
Assam	9.7	5.0	515
Chattisgarh	70.8	12.5	177
Jharkand	27.5	5.3	193
Karnataka	7.0	1.0	143
Madhya pradesh	12.2	25.8	230
Maharashtra	54.0	17.0	315
Orissa	130.2	31.9	245
West Bengal	8.0	5.0	625
India	437.0	111.0	253

### D. Oil content of niger

The niger seed usually contains 30% oil, in some accessions from Orissa in India have larger seeds than average, and medium seed types from Karnataka have higher oil content (e.g. up to 43%; Mehra and Arora 1982). The soybean and Sunflower seeds contain 18–23% oil and 38–50% of oil.

## IV. FATTY ACID COMPOSITION

Fatty acid composition generally includes saturated acids like palmitic, stearic, arachidic, monosaturated acids like palmitoleic, oleic, erucic and polysaturated acids like linoleic, linolenic. Vegetable oils ideally have high monosaturated, low saturated and polysaturated fatty acids are considered to be a suitable fuel for C.I. Engines.

SangitaYadav et al determined that the oil quality in the fatty acid composition of niger seed oil for two consecutive years and compared the results with other minor oilseed crops. And found that Niger oil has four major fatty acids namely palmitic, stearic, oleic and linoleic acid. Oleic and linoleic fatty acids showed high variability ranging from 23.52 to 53.05% and 32.03–58.28%, respectively. Total unsaturated fatty acid (81.79–85.06%) was found to be higher than total saturated fatty acid (14.94–18.21%). Based on saponification number (200.16–202.16) and Iodine value (105.69–126.7 g I 2 100 g<sup>-1</sup>) the niger oil finds its application in various industries while cetane number confirmed the use of it as biodiesel [11].

Table II. Comparison of Niger seed oil methyl ester with sunflower and soybean oil methyl esters. [12] [13] [14].

Sl no	Fatty Acid	Niger oil ME(%FA)	Sunflower oil ME(%FA)	Soybean oil ME(%FA)
1	Palmitic acid (C16:0)	8.0-9.7	5.35	10.2
2	Stearic acid (C18:0)	5.6-8.1	3.41	3.7
3	Oleic acid(C18:1)	5.9-11.0	19.58	22.8
4	Linoleic acid(C18:2)	70.7-79.2	46.87	53.7

## V. PHYSICAL AND CHEMICAL PROPERTIES:

The fatty acid composition and other properties like cetane number, viscosity etc. plays important role in selecting the efficient biodiesel. The comparison of niger seed oil ME properties are almost falls in line with the soybean and sunflower oil ME.

Table 3: Properties of niger oil methyl esters are compared with soybean and sunflower oil methyl esters [4] [15].

Sl no	property	Niger ME	Soybean ME	Sunflower ME
1	Calorific value (MJ/kg)	34	33.5	33.5
2	Cetane number	57	45	49
3	Density(kg/m <sup>3</sup> )	901	885	860
4	Kinematic viscosity (mm <sup>2</sup> / sec)	4.30(40°C)	4.5(37.80C)	4.6(37.80C)
5	Flash point(°C)	157	178	183
6	Cloud point(°C)	4	1	1

VI. USES AND BYPRODUCTS OF NIGER

Niger is cultivated as an oil seed crop, the seeds yielding about 30% of a clear, excellent, edible oil which is slow-drying, used in foods, paints, and perfumes and as an illuminant and also in industrial purposes. It is used as a substitute for olive oil, can be mixed with linseed oil, and is used as an adulterant for rape oil, sesame oil, et al. Seeds can also be used fried or as a condiment.. Seed is commonly used as food for birds. After the chemical conversion of niger seed oil into niger biodiesel, glycerin is obtained as byproduct and used in the soap production. The plant remains after threshing could be used as green manure for the soil.

VII. YIELD

Niger seed is one of the oil seed which covered under the Minimum Support Prices (MSP) given by the government through public, cooperative and other agencies designated by the state governments [16].

Statistical data on the production of niger seed vary greatly. The production is concentrated in Ethiopia and India, which had a combined annual production of about 350,000 t in the 1990s. Niger seed production in India is declining; in 1990 it was estimated at 200,000 t, in 2000 at 120,000 t. This is clearly evident from the report as below.

Table IV. Production of oil seeds/oils in India [17].

Oil seeds/oils	Quantity in Lakh tons			
	2011-12		2012-13	
	Oil seeds	oils	Oil seeds	oils
Niger seed	0.98	0.29	0.96	0.29

VIII. LIMITATIONS

The harvest index (ratio of harvested product to total plant weight) is low; fertilizer used for the crop seems to be promoting the vegetative growth rather than seed yield (Getinet and Sharma 1996, 43). Local awareness and demand for Niger seed oil in the farmers is low. The facilities and infrastructure needed for the biodiesel conversion is obsolete. Potential threats from pests and diseases to the niger were not known. Because of the hull thickness, its fibrous composition is more; hence Niger seed has a lower oil recovery rate compared to other oilseeds. More research work requires on growth, yield, usage of niger seed oil and multiple vegetable oil feedstock biodiesel conversion in India.

IX. CONCLUSIONS

In this study the niger seed methyl ester properties were compared and it seems to have a good potential to be used as a future energy biodiesel source due to its cetane number and other fatty acid compositions.

The plant *G. abyssinica* is treated as neglected underutilized crop despite being nutritionally rich, medicinally and economically important for the livelihood of

small and marginal farmers in arid and semi-arid areas of the country. The farmers are realizing importance of niger and net income nowadays. The diverse agro-ecological conditions in the country are favorable for growing the niger. The feedstock cultivation, harvest and storage to conversion technology, project finance and regulatory guidance are important considerable factors to increase the usage of niger. The Government has initiated several programmes to improve yields through better varieties, with consequent benefits to farmers and to the country through increased supply of seed available for export.

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