International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2018; 6(5): 35-38

Received: 22-07-2018
Accepted: 24-08-2018

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Variation in seed oil content among 13 populations of Mahua (*Madhuca longifolia var. Latifolia* (Roxb.) A. Chev.) in Gujarat

HT Hegde, RP Gunaga and NS Thakur

Abstract
The enormous genetic diversity of Mahua (*Madhuca longifolia var. latifolia*) in Gujarat has ample opportunity to explore the better genotypes having good oil yielding potential. For the purpose of the study, Mahua fruits were collected from 13 populations across central and southern parts of Gujarat to investigate test weight and seed dry biomass and kernels oil content. The results revealed that, the highest 100 seed weight was recorded in Kevadi population, followed by Kantipada. Considering 100 dry seed weight, Kantipada, Kevadi and Sagtal populations exhibited higher values as compared to other 10 populations. Significant variation was recorded for seed (kernel) oil content and it ranged from 29.40 to 32.35 per cent. Similarly, oil yield per kg of kernel also showed significant variation and it varied from 115.04 g (Kantipada) to 283.84 g (Kukadnakhi). Overall study shows that there was a great variation in seed size and seed oil content among studied populations; moreover, Tejgadh, Anklas and Kukadnakhi sources can be used for further selection and genetic improvement of species.

Keywords: Genetic improvement, Mahua, Population, Seed size, Seed-oil yield

Introduction
In India, domestic production of crude oil and natural gas are less as compared to the demands. There is huge gap between the demand and supply which is presently met by imports, resulting in heavy burden of foreign exchange on the country. Production of biodiesel from plant/tree based oil is considered as the best substitute for diesel. NOVOD Board based at Gurgaon, Haryana has taken various research programme on mapping and improvement of TBOs resources in order to improve the quality and quantity of biofuel in the country. Mahua (*Madhuca longifolia* var. *latifolia* (Roxb.) A. Chev.) is one among them. Mahua is valued for its seeds, which yield fatty oil known as Mahua butter and its seed oil is reported to have potential use in biodiesel production (Anon, 2010, Arora and Kumar, 2015) [1, 2]. Studies pertaining to tree selection, seed source variation for various reproductive traits, seed oil content and progeny performance have been attempted in many forest tree species in general and TBOs such as Jatropha and Karanj in particular. Such information is scanty in other TBOs like mahua; however, some studies have already been attempted in Mahua (Wani and Ahmad, 2013; Divakara and Das, 2014; Hegde *et al.*, 2017) [11, 3, 4]. Considering Jatropha as a biofuel plant, Mahua has many other potential uses from flowers and seeds. It is noted that, in the tribal areas of Gujarat, people regularly using seed oil of this species for cooking and sometimes for lightening the lamps and flowers as domestic use and also prepare some by-products (Hegde *et al.*, 2017) [4]. By looking into these usages, there is a need to domesticate this species for commercial value as well as to generate economic benefits for livelihood.
The enormous genetic diversity of Mahua in the state of Gujarat has lot of opportunity to identify the better genotypes having good oil yielding potential (Hegde, 2018) [5]. Many of the previous researches have focused on the applicability of mahua seed oil for bio-diesel and other uses; however, data pertaining to seed source variation for seed oil content in this species is scanty. Therefore, in the study, thirteen different populations of mahua in central and south Gujarat region have been screened for seed oil content.

Materials and Method
To study the inter population variation for seed (kernel) oil content, total 13 populations of Mahua were selected from central to southern Gujarat region (Table 1). Matured fruits were

collected, during May to June 2015, from randomly selected healthy good fruit bearing trees from each population and then, seeds were mixed properly and labelled. Seeds were extracted from fruits through manual depulping. The test weight (100 seed weight) was measured from all the seedlots. The seeds were then dried in hot air oven and seeds were de-shelled manually to obtain the kernel. Later, the kernels were dried in hot air oven at 65° C for 72 hrs and its dry biomass was determined. The dried kernels were crushed and fine grounded using grinding mixer. Fine ground powder was used for oil extraction. Oil extraction was made using Soxhlet method with petroleum ether (40-160^{0}C) as per standard procedure followed for estimation of oil in oilseeds and TBOs (Sadasivam and Manickam, 1996) [9]. Oil content was determined in the Food Quality Testing Laboratory, Navsari Agricultural University, Navsari and data is given in per cent. Further, 100 dry seeds weight, number of dry seeds in a kilogram (kg) and oil yield per kg of kernel was determined. The details of the study sites were given below.

Table 1: Geographical location of selected Mahua population in Gujarat

Location	Forest Division	Geo-coordinates	
		Latitude (N)	Longitude (E)
Tejgadh	Chhota Udepur	22° 21′	073° 54′
Kevadi	Chhota Udepur	22° 31′	073° 56′
Panam	Baria	22° 34′	074° 08′
Udhal Mahuda	Baria	22° 34′	074° 03′
Sagtal	Baria	22° 34′	073° 54′
Netrang	(Sub. Dvn.) Bharuch	21° 37′	073° 23′
Kantipada	(Sub. Dvn.) Bharuch	21° 40′	073° 23′
Kanchanpari	(Sub. Dvn.) Bharuch	21° 40′	073° 11′
Bilpudi	Valsad (N)	20° 30′	073° 12′
Makadban	Valsad (N)	20° 26′	073° 13′
Anklas	Valsad (N)	20° 38′	073° 16′
Taadpaad	Valsad (N)	20° 45′	073° 27′
Kukadnakhi	Dang (S)	20° 48′	073° 32′

Results and Discussion

The results showed a significant variation among 13 populations for test weight of seed, 100 dry seeds weight, number of dry seeds per kg, per cent seed oil content and oil yield per kg of kernel (Table 1 and Fig. 1). The highest 100 seed weight was recorded in Kevadi (1973 g) and Kantipada (1880 g) populations, which was followed by Sagtal population (1817 g). The lowest value for 100 seed weight was recorded in Kukadnakhi population (1370 g). Kantipada, Kevadi and Sagtal populations showed superior values for 100 dry seeds weight (Table 1). Number of dry seeds in a kilogram was estimated and it found to be maximum in Kukadnakhi population (902.50), which is almost three times more than the Kantipada population (366.95). Kernel oil content varied from 29.40 (Panam and Netrang) to 32.35 per cent (Tejgadh). Interestingly, oil yield per kg seed (kernel) was also varied significantly among 13 populations and it was highest in Kukadnakhi (283.84 g), followed by Anklas (246.28 g) and Tejgadh (192.26 g) populations (Table 1).

Seeds of many TBOs are important sources for extraction of biofuel in the country. Biofuels are important renewable and alternate source of fossil fuels. There is a great demand for biofuel in the country. As per National Biofuel Policy-2009, there is a great demand for biodiesel and bio-ethanol. More than 100 diverse tree species are producing seed oil suitable for biodiesel. Mahua is one such potential TBOs of India. In Gujarat, mahua seed oil is important for domestic consumption as a source of edible oil. Tribal people are more dependent on mahua oil for their various domestic needs. In the present study, seed oil was extracted from kernel using all the thirteen mahua populations across central to southern Gujarat. Experimental results showed that, irrespective of size of seed, seedlots collected from Kukadnakhi population exhibited highest oil recovery per kg of kernel, in spite of having lowest test weight and 100 dry seed weight. It may be due to the small sized seeds that contributed more number of seeds per kg. In contrast, when we considered the oil yield per kg, Anklas and Tejgadh along with Kukadnakhi performed better. The overall study shows that there was a great variation in oil yield with range from 115.04 g to 283.84 g oil yield per kg of kernel. Similarly, test weight of seed and seed oil per cent also showed significant variation among populations. Such inference was also reported in Mahua among 37 accessions from Tamil Nadu, which ranged from 44.40 to 61.50 per cent (Sangita Yadav *et al.* 2011) [10]. Similarly, Diwakara and Das (2014) [3] also reported great variation oil content in Mahua, which ranged from 38.3 to 50.2 per cent among 20 genotypes in Jharkhand. It is noted that, the amount of oil extracted depends on the efficiency of the equipment employed for crushing. For instance, the range is 20-30 per cent of the weight of kernels when crushed in local oil mills called Ganas, 34-37 per cent in expellers and 40-43 per cent when extracted by solvents (Kulkarni *et al.*, 2013) [6]. However, in the study, about 31 per cent seed oil was extracted from solvent method and 30 to 35 per cent seed oil content was noted from crushing mills by visiting local Ganas in south Gujarat. The study shows that variation recorded in seed oil content is attributed to genetic makeup along with geographic situation. Hence, selection can be made in the population based on higher seed oil yield.

Such geographic variation was also reported in many TBOs such as *Pongamia pinnata* with seed oil range of 31.17 - 42.0 per cent (Raut *et al.*, 2010) [8] and *Calophyllum inophyllum* seed oil yield with range of 49.3-70.4 per cent from nine seven populations along the Indian coast (Rahul, 2016) [7] and 61.81 to 79.73 per cent from 21 candidate plus trees distributed along the coast of Maharashtra (Shinde *et al.*, 2012) [11]. Though very little information is available on seed oil content of Mahua, this study shows the existence of variation among different populations in central and southern Gujarat and these information may be useful for tree breeder for improvement of this species for higher quality and quantity seed oil yield.

Table 1: Variation in seed weight and kernel oil yield among 13 populations of Mahua

Populations	Test weight of seed (g)	100 dry seed weight (g)	No. of dry seeds per Kg	Oil yield per kg kernel (g)
	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE
Tejgadh	1665 ± 06	168.44 ± 2.73	594.30 ± 9.55	192.26 ± 3.09
Kevadi	1973 ± 125	242.08 ± 2.20	413.22 ± 3.76	126.24 ± 1.15
Panam	1790 ± 14	228.73 ± 1.92	437.33 ± 3.65	128.57 ± 1.07
Udhal Mahuda	1597 ± 04	228.31 ± 2.77	438.27 ± 5.33	135.86 ± 1.65
Sagtal	1817 ± 20	231.63 ± 5.51	432.72 ± 10.36	130.68 ± 3.13
Netrang	1790 ± 27	201.46 ± 3.51	496.98 ± 8.62	146.11 ± 2.53
Kantipada	1880 ± 30	274.15 ± 11.18	366.95 ± 13.36	115.04 ± 4.19
Kanchanpari	1592 ± 13	169.51 ± 3.03	590.68 ± 10.42	186.66 ± 3.29
Bilpudi	1629 ± 20	163.59 ± 7.06	615.48 ± 24.35	186.18 ± 7.36
Makadban	1702 ± 32	169.65 ± 7.71	595.03 ± 30.68	189.52 ± 9.77
Anklas	1553 ± 24	129.73 ± 4.24	774.46 ± 27.73	246.28 ± 8.81
Taadpaad	1763.99 ± 43	196.52 ± 7.71	511.83 ± 18.97	159.69 ± 5.92
Kukadnakhi	1370 ± 11	111.67 ± 4.81	902.52 ± 40.90	283.84 ± 12.86
Grand mean	1702.17	193.50	551.52	171.30
CD at 5 % P	117.91	16.00	55.55	17.43
SEm (±)	41.43	5.62	19.52	6.12
CV (%)	5.44	6.50	7.91	7.99

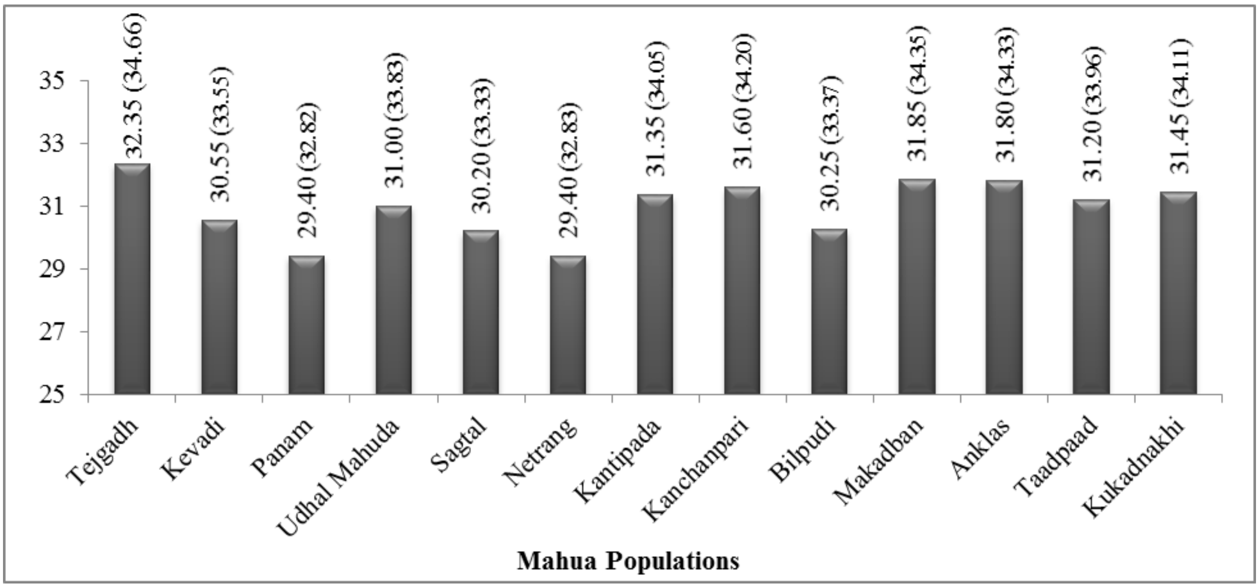

Fig 1: Variation in seed (kernel) oil content (%) among Mahua populations (n=13) in Gujarat [(Note: Figures in the parenthesis are arc-sine transformed values) (Mean=30.95; SEm(±)=0.37; CD @ 5%=1.07; CV (%);=1.88)]

Acknowledgement

Present investigation was a part of doctoral research of corresponding author. Authors express deep sense of gratitude and sincerely thanks to Navsari Agricultural University, Navsari, Gujarat for extending financial and technical support. We are very much grateful to officers and staff of Gujarat Forest Dept. for extending all the support and giving permission to conduct the field study and germplasm collection for the research purpose. We are also thankful to local community for their cooperation and help during the study.

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