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Morphological variations in populations of *Myrica esculenta* (Kaphal) in Himachal Pradesh

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Abstract
The present study was confined to 11 natural populations of *Myrica esculenta* Buch-Ham. ex D. Don distributed in three districts of Himachal Pradesh. From each population five trees were selected. Serbharal population was superior to other populations in term of tree size. Serbharal population had maximum tree height (24.40m) whereas minimum in Shilly (12.20 m) population. The maximum tree diameter (87cm) was recorded in the Serbharal population whereas minimum (63cm) in the Jaunaji population. Maximum leaf length and leaf breadth were recorded in Tutu (10.65cm) and Rajgarh (3.24cm) populations, respectively, whereas minimum leaf length and leaf breadth were found in Shogi population *i.e.* (7.63cm) and (2.40cm), respectively. Mother tree variance was higher as compared to the population and within tree variance for all the tree morphological characters. Mother tree repeatability co-efficient was higher for all the tree morphological traits ranging from 0.81 for leaf breadth, 0.82 for petiole length and 0.86 for leaf length (Table 2). Population repeatability co-efficient was low for all the parameters except tree height where it was moderate (0.38).

Keywords: *M. esculenta*, repeatability coefficient, tree height, mother tree variance

Introduction
The genus *Myrica* (family Myricaceae) includes about 97 species which are distributed worldwide except in New Zealand, Australia and Antarctica (MacDonald, 1989) [2]. Only one species of genus *Myrica* (*Myrica esculenta* Buch.-Ham.ex D. Don) has been reported in India (Anon, 1962) [1]. It is found in the sub-tropical Himalayas from Ravi Eastwards to Assam and in Jaintia, Khasi, Lushai hills and Naga at altitudes of 900-2100 m in India. In Himachal Pradesh this species is found in the districts of Chamba, Mandi, Sirmour, Solan and Shimla. It is common in Gallu forest at Jogindernagar, Shilly-Jaunji and Dochi-Chail in Solan districts (Chauhan, 2006) [3]. Besides Himalayas this species is also reported in Malaya Island, Singapore, China and Japan.

Myrica esculenta, commonly known as kaphal, is a minor and underutilized fruit. It is eaten by people since ancient times. It is a medium to large woody, evergreen tree which attains a height around 12 to 15 meters and trunk girth of 92.5 centimeters. Its bark is light brown to black in colour. The leaves are lanceolate, ovate or serrate in shape and crowding of leaves occur almost at the end of the branches. Male and female trees have almost similar appearance. The female flower is very small, solitary, sessile and bracteates with either sepals or petals which are absent or invisible. The inflorescence is of catkin type, axillary in position and bearing about 25-30 flowers in thread like style. In staminate flower inflorescence is of compound raceme and each staminate flower has about 12 stamens with very short filament each. Fruits are succulent drupe, ovoid or ellipsoidal in shape, initially green and then become reddish during ripening phase. Fruits of this species are perishable in nature and their shelf life is upto 2-3 days after harvesting. The flowering season starts from the month of October and continues till the last of December whereas fruit setting season starts from the month of November and ripe fruits are available from April to June (Jeeva *et al*., 2011) [4]. This species is very hardy and can withstands all conditions (habitat and canopy conditions) maintain significantly high male tree density and in most cases males show larger mean tree size. It can also be seen growing on the boundaries of agricultural fields or occasionally on waste and marginal lands in the hills (Rawal *et al.*, 2003) [5]. It occurs mainly with chir pine (*Pinus roxburghii*) and ban oak (*Quercus leucotrichophora*) and mixed *Quercus* forests of western Himalayas contributing 15-26 percent of the total tree density in the forest.

Myrica esculenta is a well-recognized medicinal plant since in Ayurveda and Unani system of medicine. Fruits and roots of this species are used to prepare Ayurvedic formulations such as Brahmarasayan and Chwayanprash. Its flowers claimed to treat earache; paralysis, diarrhoea and the roots have been used in asthma, cholera, bronchitis etc. (Jeeva *et al*., 2011) [4]. The presence of various bio-active phyto-constituents such as phenolic compounds, alkaloids, volatile oils, glycosides, triterpenoids were revealed by phyto-chemical studies of the different parts of plant. The plant is also reported to have innumerable significant pharmacological activities like analgesic, anti-allergic, anti-diabetic, anti-microbial, anxiolytic, antihypertensive, antiulcer, antioxidant and anti-inflammatory as evaluated by using various animal models (Patel *et al*., 2010) [6]. It acts as anti-fungal in nature (Maharjan *et al*., 2011) [7]. Its bark is widely used in the Indian systems of medicine as antiseptic, astringent carminative and in the disease supposed to be caused by deranged phlegm such as catarrhal, fever, cough and affection of throat (Anon, 1962; Kirtikar and Basu, 1984) [1, 8]. Beside the medicinal importance of *Myrica esculenta*, its bark also used in making rope and paper (Yanthan and Misra, 2013) [9]. It is a nonleguminous angiosperm *i.e.* plant which fixes nitrogen by forming root nodules called frankia. This species is also used as fuel and fodder at the time of scarcity and also the source of medicine and oil (Singh *et al.*, 1986; Shah *et al*., 2010) [10, 11].

Fruits of this species are used in making juice, syrups, jam and also consumed as raw. Local tribals use its fruits to prepare pickle and refreshing drinks. They harvest the fruits and sell it in nearby market or as road side vendors. The potential fruit yield at different habitats is 2.0 to 4.2 tonnes/ha out of which only 2 to 8 percent is harvested for income generation. The income generated from this fruit is very important considering the regional annual per capita income (Bhatt *et al*., 2000) [12].

Poor seedling establishment in natural conditions have been reported for different species of *Myrica* (Christa and Ostrofsky, 1989) [13]. This species is generally propagated by seeds but physical dormancy caused by impermeable hard seed coat results in unreliable germination pattern (Bhatt & Dhar, 2004) [14]. It shows habitat/ source specific variations in natural recruitment and seed germinability. So to sustain the supply of this tastier fruit, popularization among the local people through domestication is essential. The domestication will serve the purpose in two ways *i.e.* conservation of species and up-liftment of economic status of people.

However, to start any domestication/ Improvement programme, information regarding variability is essential. Variability helps to strategize and select the best method for specie specific improvement. Hence the present study was conducted to initiate domestication programme in this medicinally important fruit tree with the objective to study variability among fruits and seed characters of *Myrica esculenta*.

Materials and Methods

Location and climate

The present work was done in three districts *viz* Sirmour, Solan and Shimla. Total 11 sites were selected. Three populations were selected from each Solan and Shimla district whereas five populations were selected in Sirmour district. The climate of study sites is sub-tropical with cold winters. The temperature goes up to a maximum of 38 ^{0}C in summer and minimum of -0.5 °C in winters and rainfall is received in monsoon. The rainfall pattern is typical monsoon type with rainfall concentrated from July to September.

Tree morphological evaluation

Tree height (m): Height of the trees was measured by using Christen hypsometer and 2 m length wooden staff. The staff was fixed to the base of the tree at 90˚ angle and the height was measured using hypsometer at a distance of 5-10 m from the tree base. The reading for height was recorded on the hypsometer scale at coinciding top point of staff and hypsometer.

Tree diameter (cm): The diameter was calculated by actually measuring the girth. The girth was measured at breast height (1.37 m) from base of tree with the use of measuring tape. Girth was measured in cm and then converted into diameter by using following formula:

Girth (g) = 2πr

$$2r\ (d) = g/\pi$$

Leaf size (cm): The length of the leaf (cm) was measured with the help of scale from tip of the apex to the base. The width of the leaf (cm) was measured with a scale at its broadest expand.

Petiole length (cm): The petiole length (cm) was measured with the help of measuring scale.

Statistical analysis

Data was analyzed in Generalized Linear Model (GLM) procedure type III sums of square. The statistical model used was:

$$Y_{ijk} = \mu + p_i + M(p)_{j(i)} + e_{ijk}$$

Where:

μ = grand mean

p_i = effect of ith natural population (i=1, 2.....p)

$M(p)_{j(i)}$ = the jth mother tree effect within each ith natural population

e_{ijk} = the interaction of the kth observation and jth mother tree in the ith natural population

Natural population effects were considered fixed and all other effects were considered random. LSD test was used to determine if differences among Natural population and mother tree within population were significant.

Result and Discussion

Tree height revealed that Serbharal population had maximum tree height (24.40m) whereas minimum in Shilly (12.20 m) population. The maximum tree diameter (87cm) was recorded in the Serbharal population whereas minimum (63cm) in the Jaunaji population. The height showed significant correlation with diameter. Risi and Galwey (1989) [15] had similar results for *Chenopodiuin quinoa* Willd. Significant differences were seen in height characteristics among populations (Table 1).

In case of leaf characteristics the maximum petiole length was recorded in Bagpashog population (1.40cm) whereas minimum was observed in Bisha population (0.84cm).

Maximum leaf length and leaf breadth were recorded in Tutu (10.65cm) and Rajgarh (3.24cm) populations, respectively, whereas minimum leaf length and leaf breadth were found in Shogi population *i.e.* (7.63cm) and (2.40cm), respectively. Verwijst and Wen (1996) [16] found that the leaf length and leaf width ratio also changed with leaf size which varied between different types of shoots in salix species and in wild pomegranate (Negi, 2019) [17].

Table 1: Variation among population for tree height, tree diameter, petiole length leaf length and leaf breadth in *M. esculenta*

Region	Population	Tree height (m)	Tree diameter (cm)	Petiole length (cm)	Leaf length (cm)	Leaf breadth (cm)
Shimla	Shogi	13.60	67.00	1.28	7.63	2.40
	Taradevi	17.40	67.00	1.04	9.08	2.67
	Tutu	15.00	66.00	1.25	10.65	3.21
Sirmour	Bagpashog	14.40	66.00	1.40	8.67	2.83
	Chakala	17.60	73.20	1.11	9.25	2.69
	Dabara Baranji	18.20	70.40	1.29	10.53	2.98
	Rajgarh	15.80	74.00	0.98	8.66	3.24
	Serbharal	24.40	87.00	1.04	8.94	3.04
Solan	Bisha	17.40	64.40	0.84	10.15	2.95
	Jaunaji	13.20	63.00	0.99	8.82	3.21
	Shilly	12.20	83.20	1.20	9.99	3.19
LSD				0.09	0.49	0.18

Phenotypic variation between mother trees for tree height, tree diameter, petiole length, leaf length and leaf breadth

The variations in phenotype of the tree morphological characters would be attributed to mother tree. Mother tree variance was higher as compared to the population and within tree variance for all the tree morphological characters. Relative contribution of mother tree variance to the total variance was higher for leaf length (72.59%) and leaf breadth (71.28%) however contribution by mother tree shown for petiole length was 65.50%. Within tree variation contributed low to total phenotypic variation except for tree diameter characteristics *i.e.* (226.27%). Mother tree repeatability co-efficient was higher for all the tree morphological traits ranging from 0.81 for leaf breadth, 0.82 for petiole length and 0.86 for leaf length (Table 2). Population repeatability co-efficient was low for all the parameters except tree height where it was moderate (0.38) (Table 2). Similar findings have been reported by the Sanou *et al.*, (2006) [18] in *Vitellaria paradoxa*; Chegini *et al.*, (2016) [19] in *Olea europaea* L. and Kumar, (2015) [20] in *Terminalia chebula*.

Table 2: Variance component and repeatability coefficient for tree morphological characters in *M. esculenta*

Parameters	Natural Population	Mother Tree (population)	Within Tree	R_{mt}	Rp
Tree height	8.48	-	13.92	-	0.38
Tree diameter	15.61	-	226.27	-	0.06
Petiole length	19.65	65.50	14.85	0.82	0.20
Leaf length	15.49	72.59	11.92	0.86	0.15
Leaf breadth	12.49	71.28	16.24	0.81	0.12

Conclusion

The present study shows that significant variation was observed for morphological characters in different populations of *M esculenta*. The site Serbharal showed maximum height and diameter. These sites can be used for further propagation as immediate source for good quality plant production. Further Mother tree variation was observed higher as compared to population variance so intra-population variation studies are required to create assistance roadmap for further improvement and domestication for this important, however vulnerable species.

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