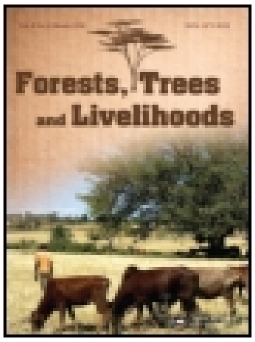


Forests, Trees and Livelihoods

ISSN: 1472-8028 (Print) 2164-3075 (Online) Journal homepage: https://www.tandfonline.com/loi/tftl20

# Morphological characterization of guggal (*Commiphora wightii*) provenances from extremely arid parts of India

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*Forests, Trees and Livelihoods*
Vol. 21, No. 1, March 2012, 63–69



# Morphological characterization of guggal (*Commiphora wightii*) provenances from extremely arid parts of India

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*Commiphora wightii* is one of the major guggal gum-resin producing species in India. It has never been brought under cultivation and the species is now considered endangered. Growth performances and morphological parameters were assessed during 2008 and 2009 at Jaisalmer, in the hyper arid part of India, for five provenances of *Commiphora wightii*, viz., Dantiwara, Mangaliawas, Kukma-Bhuj, Bhind-Murena, and Jaisalmer local. Observations revealed a significant amount of variation for plant height, stem girth, number of branches per plant, crown spread, leaflet shape, and 100 seed weight. The provenances have shown measurable growth responses, which were sufficient for a conclusive remark. Such variation among different populations may be due to different intensities of natural selection acting upon the traits in their natural habitat. Results of this study are important for the conservation of the genetic variation of the species and for future improvement schemes: they indicate that genetic differences exist among provenances of guggal (*Commiphora wightii*), with Jaisalmer local, Mangaliawas, and Dantiwara showing satisfactory performance for cultivation in arid parts of India.

**Keywords:** growth performance; afforestation; genetic variation; morphology

## Introduction

*Commiphora wightii* (Arn.) Bhandari, the guggal of the family Burseraceae, is a small shrub, characterized by a thick main stem with crooked knotty branches. It is used in the allopathic, ayurvedic, and unani systems of medicine due to its anti-inflammatory, antirheumatic, hypocholesteremic, hypolipidemic, anti-fertility, and anti-cancer activity, due to the presence of oleo-gum resin in its exudates, commonly known as guggal, Indian myrrh, or Indian bdellium (Satyawati 1991; Singh et al. 2007; Tajuddin et al. 1997; Xiao and Singh 2008). *C. wightii* has become endangered—the plant is classified in the Data Deficient category of International Union for Conservation of Nature's (IUCN) Red Data list—because of its slow growth, poor seed setting and seed germination rate, lack of cultivation, and excessive and unscientific tapping (Mertia et al. 2010). Destructive harvesting of its oleo-gum resin for pharmaceutical and industrial uses is one major cause of the decline in plant populations of the species (Mertia et al. 2010). Moreover, intra-specific variation in *C. wightii* population was reported as high, which may lead to the disruption of population continuum (Haque et al. 2009). In India, *C. Wightii* is found in arid, rocky tracts of Rajasthan, Gujarat, Maharashtra, and Karnataka states, with Rajasthan and Gujarat as the main Indian commercial centers (Mertia et al. 2010). In the last few

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ISSN 1472-8028 print/ISSN 2164-3075 online

http://dx.doi.org/10.1080/14728028.2012.669579
http://www.tandfonline.com

decades, there has been a sharp decline in natural populations of this species and there is hardly any commercial cultivation (Mertia et al. 2010). The increasing commercial demand of gum resin is putting further pressure on this endangered species. This pressure can be reduced through cultivation of suitable landraces in its natural habitat.

Guggal vary greatly in their morphological characteristics. The size and shape of different plant parts are used for differentiating provenances (Galan 1989). However, no systematic attempt for collecting and conserving guggal germ plasm has been made in India. Only a few provenances are available, which are collected from different locations and perpetuated through seed and other vegetative methods of propagation. Ethnobotany (Hocking 1993), anatomy (Shah et al. 1982), and ecology (Dixit and Subba Rao 2000) of the species have been well documented but there is no literature until now which indicates that different provenances of guggal differ in their morphological characteristics and growth performances. The aim of the study was thus to determine source variation in *Commiphora wightii* provenances collected from different locations in arid and semi-arid parts of India and to identify the best sources for use in future afforestation and genetic improvement schemes.

## Materials and methods

Five guggal provenances were collected in 2001 from five different regions within arid and semi-arid tracts of northwestern India. They were then planted at the research farm of Central Arid Zone Research Institute (CAZRI), Regional Research Station, Jaisalmer. The five provenances are referred hereafter according to the region of collection: Dantiwara, Mangaliawas, Kukma-Bhuj, Bhind-Murena, and Jaisalmer local. Detailed information on soil and climate of each region from where these guggal provenances were collected is mentioned in Table 1. Each region was field traversed and a natural habitat of guggal plant

Table 1. Information on soil and climate of the regions from where the guggal provenances were collected.

| Provenance | Average rainfall | Average elevation from mean sea level | Soil type | General physiography |
|---|---|---|---|---|
| Dantiwara | 550–600 mm | 500–600 m | Fine loamy, mixed hyperthermic, typic Haplustepts | Moderately sloping undulating aeo-fluvial plains |
| Mangaliawas | 500–600 mm | ~360 m | Fine loamy, mixed (calcareous) hyperthermic, Aridic Haplustepts | Young alluvial plains |
| Kukma-Bhuj | 300–400 mm | 120–140 m | Fine loamy, mixed (calcareous) hyperthermic, Ustochreptic Haplocambids | Nearly level arid plains |
| Bhind-Murena | 700–750 mm | 175–200 m | Coarse loamy, mixed hyperthermic, Fluvic Haplustepts | Rolling topography with ridge sedimentary |
| Jaisalmer local | <200 mm | ~200 m | Sandy, mixed (calcareous) hyperthermic, Typic Petrocalcids | Buried pediments |

was identified from where vegetative cuttings of 8–10 mm in thickness were collected from randomly selected healthy plants of different ages (Table 1).

During 2008–2009, growth performances of the guggal provenances were evaluated. Oleo gum resin production has not been evaluated because production has not begun. Layout of the guggal provenances plantation is presented in Figure 1. Five plants representative of each provenance in terms of size and vigor were selected for the study, and their morphological characteristics were recorded (Figure 1). Plant height and canopy spread were recorded by measuring height and width of each selected plant. Plant growth habit, shape, stem bark colour, and branching type were recorded by visual observation of the plants. From each selected plant, 10 leaves, 10 flowers, and 10 fruits were randomly collected to record their morphological characteristics. On leaves, orientation, shape, leaflet length, leaflet width, and leaf colour were recorded. On flowers, colour and type of attachment were recorded. On fruits, size, shape, and colour were recorded along with the hundred seed weight (recorded from sun-dried seeds). The collected morphological data were analyzed statistically using the SPSS 13.0 software package, using Tukey's Multiple Range Test, to determine differences among five guggal provenances. The experimental design for the statistical analysis was considered as a randomized complete block design (RCBD), with the five guggal provenances considered as different treatments and the five selected plants from each provenance considered as replications (see Figure 1).

## Results

The plant characteristics of the five guggal provenances are presented in Table 2. The plant growth habit of the selected guggal provenances was erect to sub-erect; the stem bark was mostly greenish to brownish; the canopy was round and almost symmetrical; the branching was knotty and crooked and in some cases divaricated. Mangaliawas and Jaisalmer local

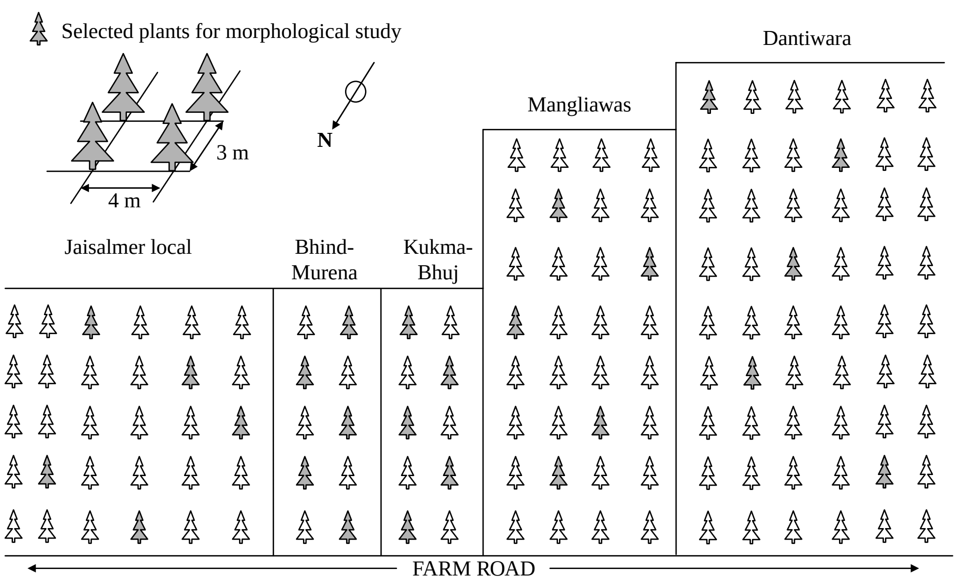


Figure 1. Design of the guggal provenances plantation in the research farm of the Central Arid Zone Research Institute at Jaisalmer, India.

Table 2. Morphological characteristics of the five guggal provenances.

| Provenances | Plant growth habit | Canopy spread (cm) | Stem bark colour | Plant shape | Branches/plant | Branching type | Plant height (cm) | Stem girth (mm) |
|---|---|---|---|---|---|---|---|---|
| Dantiwara | Sub-erect | $302.2 \pm 5.2^{c}$ | Greenish-white | Round, dense, less symmetrical canopy | $7 \pm 1.5^{ab}$ | Knotty and crooked | $196.8 \pm 3.7^{b}$ | $51.6 \pm 1.9^{b}$ |
| Mangaliawas | Erect | $421.7 \pm 5.3^{d}$ | Greenish-brown | Round, dense, symmetrical canopy | $11 \pm 0.6^{b}$ | Divaricated | $253.0 \pm 10.3^{c}$ | $58.5 \pm 3.1^{b}$ |
| Kukma-Bhuj | Sub-erect | $205.5 \pm 2.9^{b}$ | Brownish-green | Round, dense, less symmetrical canopy | $7 \pm 1.2^{ab}$ | Moderately knotty and crooked | $164.5 \pm 6.0^{ab}$ | $50.4 \pm 1.6^{b}$ |
| Bhind-Murena | Sub-erect | $126.4 \pm 5.5^{a}$ | Greenish-yellow | Round, less dense, non-symmetrical canopy | $3 \pm 0.6^{a}$ | Slightly divaricated | $151.4 \pm 7.9^{a}$ | $36.1 \pm 2.7^{a}$ |
| Jaisalmer local | Spreading type | $405.8 \pm 3.7^{d}$ | Greenish-brown | Round, dense, symmetrical canopy | $11 \pm 0.6^{b}$ | Highly knotty and crooked | $249.8 \pm 5.5^{c}$ | $54.6 \pm 2.6^{b}$ |

Note: Values are mean of 10 replications ± SE. Cells in columns with the same letters are not significantly different ($P < 0.05$, Tukey test).

provenances showed statistically superior performances in canopy spread, number of branches per plant, plant height, and stem girth. The performance of Bhind-Murena provenance for the aforesaid characters was poor (Table 2).

The leaf characteristics of each provenance are presented in Table 3. Leaf attachment was sub-sessile to sessile; leaflets were generally ovate and light green to dark green in colour. Leaflet length and width varied among provenances, with the Kukma-Bhuj provenance having significantly larger leaflets than the other provenances (Table 3).

The flower, fruit, and seed characteristics of guggal provenances are presented in Table 4. Flower attachment was either solitary or fascicled, light red to pinkish red in colour. Fruit color varied highly among the guggal provenances from deep brown for Jaisalmer local to crimson red for Dantiwara. Fruit size was highest for Jaisalmer local and lowest for Kukma-Bhuj. Fruits were highly variable in shape. One-hundred-seed weight was highest for Jaisalmer local (Table 4).

## Discussion

The differences in morphological characteristics among the five guggal provenances studied here might be related to the differences in soil and climatic conditions of the areas where they were collected. For example, Jaisalmer local provenance, which naturally grows in the soil and climate conditions of the experimental site, performed better than the other provenances. In contrast, Bhind-Murena provenance, which grows in soil and climate conditions that are very different from those found in Jaisalmer, had poor performance.

A higher number of branches per plant generally reflects a potential to survive under extreme arid conditions. Jaisalmer local and Mangaliawas have more branches per plant than the other provenances, which could be interpreted as a sign of higher adaptability to the extreme arid condition of the Indian Thar desert. The variation in branching type might be due to differences in adaptive features for survival under extremely fragile habitat of arid region. Vigor in stem girth is an important morphological character of any plant for long-term establishment in arid zones. Arid areas are generally characterized by high wind velocity ($\sim > 15\,\text{km hr}^{-1}$) throughout the year, which may result into uprooting of plants or breakage in the collar region of the stem. In this study, Jaisalmer local and Mangaliawas had higher stem girth than other provenances and thus may have a better ability to withstand the extreme weather of the Indian arid region.

Table 3. Morphology of leaves of the five guggal provenances.

| Provenances | Attachment | Leaflet length (cm) | Leaflet width (cm) | Leaflet shape | Leaflet colour |
|---|---|---|---|---|---|
| Dantiwara | Sub-sessile | $2.51 \pm 0.02^{bc}$ | $1.42 \pm 0.01^{a}$ | Highly ovate | Green |
| Mangaliawas | Sessile | $2.44 \pm 0.03^{b}$ | $1.74 \pm 0.03^{c}$ | Ovate | Dark green |
| Kukma-Bhuj | Sub-sessile | $2.62 \pm 0.02^{d}$ | $1.92 \pm 0.02^{d}$ | Moderately ovate | Light green |
| Bhind-Murena | Sub-sessile | $2.54 \pm 0.02^{cd}$ | $1.86 \pm 0.02^{d}$ | Moderately ovate | Light green |
| Jaisalmer local | Sessile | $2.32 \pm 0.02^{a}$ | $1.62 \pm 0.02^{b}$ | Rhomboid ovate | Dark green |

Note: Values are mean of 10 replications ±SE. Cells in columns with the same letters are not significantly different ($P < 0.05$, Tukey test).

Table 4. Morphological characteristics of flower, fruit, and seed of the five guggal provenances.

| Provenances | Flower attachment | Flower colour | Fruit colour | Fruit size (mm) | Pyrene shape | 100-seed weight (g) |
|---|---|---|---|---|---|---|
| Dantiwara | Fascicled | Light red | Crimson red | $6.8 \pm 0.2^{ab}$ | Dome shaped | $3.84 \pm 0.02^{c}$ |
| Mangaliawas | Fascicled | Pinkish red | Brownish red | $7.4 \pm 0.3^{bc}$ | Slightly ovate | $4.15 \pm 0.02^{d}$ |
| Kukma-Bhuj | Solitary | Light red | Reddish green | $6.2 \pm 0.4^{a}$ | Pear shaped | $3.32 \pm 0.02^{b}$ |
| Bhind-Murena | Solitary | Light red | Reddish green | $6.5 \pm 0.3^{a}$ | Ellipsoidal | $2.95 \pm 0.02^{a}$ |
| Jaisalmer local | Fascicled | Pinkish red | Deep brown | $7.9 \pm 0.3^{c}$ | Ovate | $4.58 \pm 0.03^{e}$ |

Note: Values are mean of 10 replications ±SE. Cells in columns with the same letters are not significantly different ($P < 0.05$, Tukey test).

The leaf size (length and width) showed some variation among provenances, confirming that leaf size in *C. wightii* may be used for provenance identification, as in litchi (Singh et al. 1999). The flower colour, fruit colour, and fruit shape are genetic traits that may also be used for provenance identification. The extent of variation in seed weight was large compared to the other traits. The 100-seed weight was found highest for Jaisalmer local, which confirms the superiority of this provenance in this context.

## Conclusion

In this study, five guggal provenances were evaluated in the extreme arid region of the Indian Thar desert at Jaisalmer. Morphological characters of stems, branches, leaves, flowers, fruits, and seeds were found widely variable among provenances. A considerable amount of genetic variability also exists in this species with respect to growth performance, which offers scope for selection and breeding. The Jaisalmer local and Mangaliawas provenances have the best performance in the prevailing conditions at Jaisalmer, characterized by a meager amount of annual rainfall ($<160$ mm with coefficient of variation $> 80\%$), extreme temperatures (- 4°C to 48°C), high wind speed during hot summer months (mean daily wind speed 18 km $hr^{-1}$), and a very high rate of evapotranspiration (10–15 mm $day^{-1}$ during summer months). However, provenance Dantiwara also performed satisfactorily with respect to growth and 100-seed weight. Although oleo-gum resin production has not been evaluated, these three sources can safely be used for large-scale afforestation programmes in the region.

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