



Non-destructive harvesting of oleo-gum resin in *Commiphora wightii* (Arnott) Bhandari—A critically endangered plant

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ABSTRACT

Commiphora wightii (Arnott) Bhandari is an immense medicinal important plant. It yields a valuable oleo-gum-resin which is widely used in Ayurvedic medicines. The traditional destructive method for guggul gum harvesting was one of the causes for its population decline and making this plant critically endangered. Present study was conducted on two sites viz. Jodhpur, Rajasthan and Bhuj, Gujarat. It describes the effect of season, cut size, cut orientation and girth on gum yield. Monthly observation revealed winter season (November to February) as best period for guggul gum harvesting when average gum yield was 4.22 ± 0.44 g per plant. A significant variation was found in gum yield due to different cut sizes ($F = 5.076$, $P < 0.01$) and different cut orientations ($F = 5.106$, $P < 0.01$). Gum yield increased with cut size and horizontal cut was the best for gum harvesting. Regression analysis between gum yield and girth class at two sites was positively correlated ($R^2 = 0.239$, $F = 2.430$, $P < 0.01$). Some putative high gum yielder genotypes were also identified through regression analysis. There were no casualties in any of the experimental plants irrespective of treatments given even after three years at Jodhpur and two years at Bhuj site. Injuries were healed up within two months and plants remained as healthy as non-treated plants.

1. Introduction

Commiphora wightii (Arnott), locally called as ‘Guggal’ is known for its Oleo-gum resin ‘Guggul’ which has very high demand in national and international herbal industries. This plant is exploited for tapping gum by the tribal in an unscientific manner, causing high mortality and decline in its population density. In addition to this, slow growing nature, poor seed setting, germination and regeneration and lack of cultivation practices also contributed in its population decline. Presently, this important medicinal plant is categorized as critically endangered species by IUCN’s Red list (Ved et al., 2015). In India, its distribution is restricted to Rajasthan, Gujarat, Madhya Pradesh, Karnataka and Kalat division of Andhra Pradesh (Soni, 2010; Dixit and Rao, 2000; Khan, 1958). Rajasthan is having largest area covering guggal population but density is still very poor. Highest density of guggal is reported in Sawai Madhopur (≈ 74 plants ha^{-1}) and Jhunjhunu (≈ 69 plants ha^{-1}) districts of Rajasthan (Tomar, 2013).

National Medicinal Plant Board, Ministry of Ayush, New Delhi has considered it as one of the priority species for research and development (Kala and Sajwan, 2007). Oleo-gum resin is obtained from bark of this plant and has potent medicinal uses mainly in arthritis, bronchitis, cholesterol reduction, hyperlipidaemia, atherosclerosis and coronary

artery disease (Jain, 1991; Satyavati, 1991; Wu et al., 2002; Badmaev and Majeed, 2000). The trend of guggul gum collection has declined rapidly in recent past due to destructive harvesting practices and population decline. The collection of gum resin was 30 tons in 1963, that drastically reduced to 2.42 ton in 1999 (Dixit and Rao, 2000). Actual demand of guggul gum in India is about 1000 MT annually, but the production is only 100 MT. The deficit is met via import from Pakistan and Afghanistan, for which India pays about 45 crores rupees annually (Maheshwari, 2010).

The traditional unscientific methods of making several deep incisions in stem and applying of a paste containing guggul gum and copper sulphate though increase the gum yield but leads to high mortality in plants (Atal et al., 1975; Soni and Swarnkar, 2006; Kaser and Prakash, 2005; Kshetrapal and Sharma, 1993). In past, many researchers worked on improvement of oleo-gum resin harvesting practices. Bhatt et al. (1989) treated 27 plants with 100, 200 and 400 mg concentrations of ethephon in three different ways. They reported maximum 880 g cumulative gum yield in three successive years with 400 mg ethephon applied through roots, which is equivalent to 32.6 g of gum harvested per plant each year. Arya et al. (2013) conducted tapping experiment by giving three semi-circular cuts (half of the stem or branch girth) and used three concentrations (150, 300 and 450 mg) of ethephon

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combined with irrigation and fertilizer. Maximum 35.8 g per plant gum yield was observed with 450 mg ethephon treated plants. In this treatment, 42% mortality was recorded. A much higher gum yield (175 ± 9.0 g plant⁻¹) was reported by Samanta and Mandal (2014) with a bacterium (*Xanthomonas axonopodis* pv. *Commiphorae*) treatment at five positions (main trunk and branches) on a plant. However, all bacteria treated plant died gradually after the gum exudation.

The major drawbacks in above investigations were lack of scientific field design and proper statistical analysis. Moreover, methodology is not uniform in these investigations like orientation and number of cuts per plant and thus results are not comparable between each other. None of these researchers considered the effect of girth size in their experiments, which can be an important factor for gum yield as girth size found to play a significant role in gum yield in many species like *Boswellia serrata* (Sinha et al., 2016; Mishra et al., 2012), *Sterculia urens* (Mishra et al., 2012) and *Acacia senegal* (Pareek et al., 2017; Unanaonwi and Bada, 2013). Present investigation was carried out with the objective to develop sustainable non-destructive guggul gum harvesting method. Proper experiments were conducted to study annual pattern of gum yield, effect of cut size and orientation and correlation of gum yield with girth size of the plant without using of enhancers so that casualties could be minimised.

2. Materials and methods

2.1. Study sites

Studies were carried out at two locations, viz. Kumatia enclosure forest block at Kailana hills area in Jodhpur district of Rajasthan state and Ler forest block in Kutchh-Bhuj district of Gujarat state. Climatic conditions and soil properties of both sites are given in Table 1. Naturally growing 60 plants in 4.5 ha were selected in Kailana site, Jodhpur and 60 plants in 2 ha area were selected in Ler site for tapping experiments. Data on height, crown, girth size and GPS positions of each selected plant were recorded (Table 1). The annual data on rainfall, minimum and maximum temperature and relative humidity at 6 O'clock in the morning and at 6 O'clock in the evening in monthly values were obtained from CAZRI (Central Arid Zone Research Institute), Jodhpur.

Table 1
General properties of selected experimental sites.

	Kailana, Jodhpur (Rajasthan)	Ler, Bhuj (Gujarat)
GPS Positions	26°19N; 72°57 E	23°17N; 69°76E
Guggal density (Plants ha ⁻¹)	13	30
Average girth size (cm)	34.0 ± 0.82	34.0 ± 0.72
Average Height (cm)	179.71 ± 6.18	210.33 ± 3.58
Average Crown (cm)	255.65 ± 11.07	301.75 ± 5.11
Annual Rainfall (mm)	323	413
Rainy days	61	85
RH I (%)	69	82
RH II (%)	36	44
Annual Temperature (°C)		
Maximum	34.4	32.0
Minimum	16.9	17.9
Soil type	Desertic soil	Desertic and saline soil
Soil pH	8.18	7.59
Soil EC (dS m ⁻¹)	0.14	0.40
SOC (%)	0.45	0.52
Total Nitrogen (%)	0.05	0.0006

EC = Electrical conductivity. RH I = Relative Humidity at 6 O'clock morning. RH II = Relative Humidity at 6 O'clock evening; SOC = Soil Organic Carbon.

2.2. Season

In Jodhpur, weather conditions can be divided into three seasons, viz. rainy (July–October), winter (November–February) and summer (March–June). So, the plants growing in this zone adapt themselves accordingly. Therefore, an experiment was conducted to study the annual pattern of gum production by this plant and to find out the best season for oleo-gum resin harvesting.

Sixty plants having a more or less uniform girth (28.05 ± 0.66 cm) were selected at Kailana site, Jodhpur in Rajasthan. Five plants were tapped by inflicting single 8 cm horizontal cut on three branches in the second week of every month. Experiment initiated in September 2015 and completed in August 2016. Plants started gum oozing immediately after the cut and continued upto a week. Total gum oozed out was collected after seven days in zip lock polybags and air dried at room temperature (28 °C) for 25 days before weighing.

2.3. Cut size and orientation

Second experiment was conducted at two different sites viz. Kailana, Jodhpur and Ler, Bhuj in the month of March 2014 and 2015 respectively. The experiment was conducted with twelve treatments which included the combinations of four cut sizes (1.0, 2.0, 3.0 and 4.0 cm) and three orientations (Horizontal, Oblique at 45° angle and Vertical). As the bark thickness of the plant varied from 1.8 mm to 2.0 mm (Thomas et al., 2010), the depth of the incision was kept at 2 mm in all the treatments. Average girth of the treated branches was 18.24 ± 0.34 cm at Kailana and 19.39 ± 0.35 cm at Bhuj. Tapping was done in five plants, wherein three branches from each plant were selected for treatments to harvest guggul gum. Therefore, a single incision was made on total fifteen branches (5 plants × 3 branch) in each treatment. A total of 180 observations were recorded for twelve treatments at each site. Data on collar and branch girth of individual plant were also recorded for correlation and regression analysis. The extracted gum resin was collected as described in previous paragraph.

2.4. Monitoring of tapped plants

Previous literatures reported the casualties in gum harvested plants using different enhancers like resin suspension solution (Yadav et al., 1999), ethephon (Arya et al., 2013; Bhatt et al., 1989) and bacteria inoculation (Samanta and Mandal, 2014). Therefore, in present investigation a criteria was prepared (Table 2) for monitoring of plant health after tapping experiments. Accordingly, data on the health of the plants were recorded at regular interval of six months up to 3 years on the main trunk, primary branches and secondary branches.

2.5. Statistical analysis

Data were analysed using ANOVA test to observe the effect of cut sizes and cut orientations on gum yield using SPSS version 22. Pearson's correlation coefficients were calculated for the relationship between gum yield per plant and climatic variables. Correlations between gum production and different girth sizes were also examined at both sites using regression curve estimation. Positive outliers identified after

Table 2
Criteria for giving relative score on health conditions of the plant.

Relative score	Health condition
5	Cut fully healed, all branches succulent and no disease
4	Cut is not healed, infection observed, about 10% branches dried
3	Cut is not healed, infection observed, about 30% branches dried
2	Cut is not healed, moderate infection, about 50% branches dried
1	Cut is not healed, heavy infection, about 80% branches dried
0	Complete death of the plant

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