PROJECT COMPLETION REPORT

on

Standardization of sustainable harvesting practices of Mahul Patta (*Bauhinia vahlii*)

(April, 2011 – November, 2014)

Submitted to

Chhattisgarh State Minor Forest Produce Federation Ltd.,
Raipur, Chhattisgarh

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PROJECT PROFILE

1. Project Title	:	Standardization of sustainable harvesting practices of Mahul Patta (*Bauhinia vahlii*)
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3. Name of PI	:	Dr. A.K. Pandey , Scientist – F (till 14th June,2013) Mrs. Neelu Singh, Scientist – E (from 15th June , 2013)
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7. Year	:	April, 2011-November,2014
8. Species selected	:	*Bauhinia vahlii* (Mahul Patta)

CONTENTS

INTRODUCTION

Bauhinia vahlii Wight & Arontt (Family- Leguminosae) is a gigantic, usually evergreen climber (Fig.1), commonly known as Mahul. The species is distributed in the Sub-Himalayan region up to 3,000 m above sea level, tropical moist and dry deciduous forests of Central India, Bihar, Eastern and Western Ghats. It is also called as camel's foot climber as the leaves (Fig.2) are similar to a camel's foot print.

It is the largest creeper in India, and can grow up to 10-30m long. Leaves are compound, alternate, with leaf petiole and 11-15 nerved at the base, almost orbicular in shape and vary in size up to 45 cm long (Fig.2).The flowering in Mahul occurs between April and June. Flowers (Fig.3) are white or buff in long peduncled terminal sub corymbose racemose, numerous and 2.5–8 cm long. Fruits are in the form of pods, woody, rusty tomentose, 6-12 seeds in each pod, sub orbicular, 2.5 cm diameter, flat and dark brown in colour. The seeds are considered aphrodisiac and tonic. A fairy long time interval (10-12 months) between pod formation and maturation does not ensure adequate supply of seeds for regeneration in natural conditions (Upreti and Dher,1996).

B.vahlii is an important species of economic value in the tribal belt of central region. The leaf is used by the grocery shops, eateries etc. as plates and packing material (Fig.4). The plates made of Mahul leaves are used exclusively during the community feasts and rituals. The stem fibre is used for making ropes, basketry and wickerwork. The outer bark yields 17% tannin and 19% non-tannins. The root and bark have medicinal properties. Seeds of the plant are eaten both raw and fried.

Mahul leaves are available for collection around 9-10 months in a year, making it an almost year round livelihood option. The leaves are collected by local tribal people. The average collection per person per day is around 5 to 6 kilograms, which is sold in the market without additional processing (Patrick *et al*., 1994). The demand for Mahul Patta, both in India and abroad has been growing rapidly for quite some time. The collectors harvest Mahul leaves unscientifically often by damaging the plant to obtain maximum leaves. Such unsustainable harvesting methods lead to depletion of the plant vigour. The commercial collection of leaves not only damages the plant but also reduces its population in the natural forests at an alarming rate

(Mishra and Teki, 2007). Very few studies have been made on the impact of harvesting of leaves on the quality as well as natural regeneration, density and productivity of the species in the natural forests.

Keeping in view the economic significance of Mahul Patta, The Chhattisgarh Minor Forest Produce Federation, Raipur funded a project for standardization of sustainable harvesting practices for *Bauhinia vahlii.* The objectives of the project are as follows:

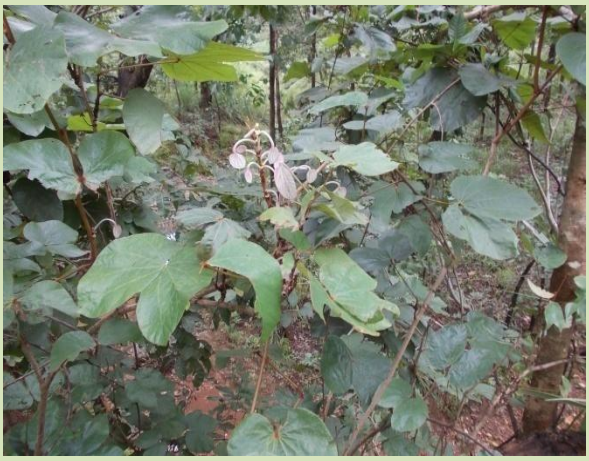


Fig.1 Climber of *B.vahlii*

Fig.2 Leaves of *B.vahlii*

Fig.3 Flowers of *B.vahlii*

Fig.4 Plates prepare of *B.vahlii leaves*

OBJECTIVES

- To develop sustainable harvesting practices for *Bauhinia vahlii* leaves.
- To study influence of harvesting time on regeneration of the species.
- To evaluate influence of harvesting time on quality of leaves.

METHODS AND MATERIALS:

Site selection

Surveys were conducted in the natural forest areas of Marvahi (Biashpur), Kathghora forest divisions of Chhattisgarh for selection of Mahul growing areas and to layout experiments on sustainable harvesting of Mahul leaves.

STUDY AREA:

Study Site: The present study was carried out at three sites in Chhattisgarh.

SITE-(I): Keochi, Marvahi forest division (Bilashpur, Chhattisgarh) which lies between 29^0 39" and 29^0 39" N^0 latitudes and $81^0$43"and $81^0$43" E^0 longitudes. It is situated at an altitude of 2640 ft. above sea level surrounded with thick Sal forest

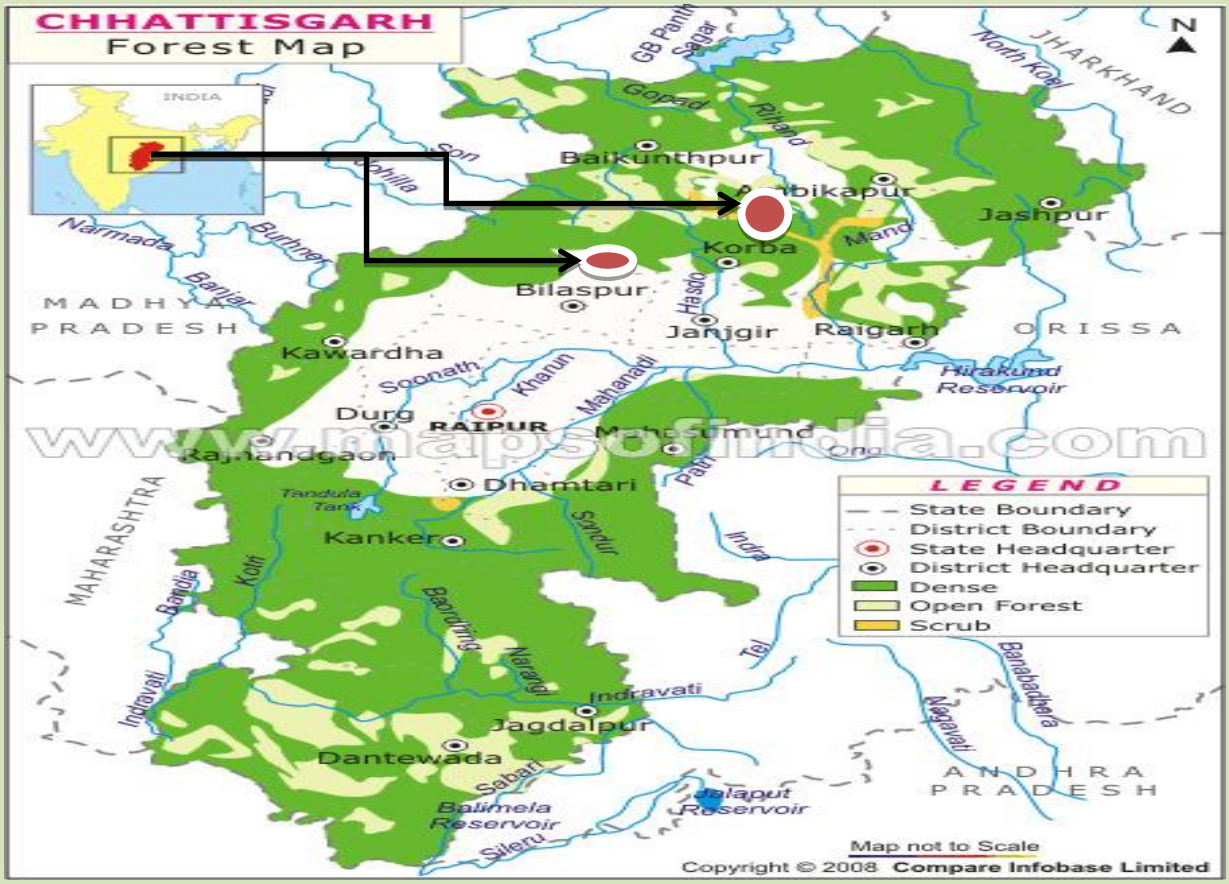


Figure-5 Map showing the study area of experimental plots Chhattisgarh state

SITE-(II): Sapalwa Pahadi (Pali), Kathghora forest division (Korba, Chhattisgarh) which lies between 22^0 32" and 22^0 32" N^0 latitudes and $82^0$17"and $82^0$17" E^0 longitudes. It is situated at an altitude of 2539 ft. above sea level surrounded with thick Sal forest.

SITE-(III): Lamani core area (Achankmar Kumar Tiger Reserve) protected area at Marwahi forest division (Bilashpur, Chhattisgarh) which lies between 22^0 32" and 22^0 32" N^0 latitudes and $81^0$38"and $81^0$38" E^0 longitudes. It is situated at an altitude of 2640 ft. above sea level surrounded with thick Sal forest.

Climate

The area experiences tropical monsoon climate with three seasons in a year, viz. summer (April to June), rainy (July to September) and winter (November to February). The months of March and October constitute transition periods, respectively between winter and summer, and between rainy and winter seasons.

Standardization of harvesting limits

Experiments initiated in 2012:

Experiments related to harvesting intensities were laid out in the forest areas of Keochi, Marvahi; Futka Pahad, Balco (Korba) and Pali, Katghora forest divisions of the state in 2011-2012. At each study site 25 quadrates of 10x10m were laid out in randomized design.

To standardize sustainable harvesting limits leaves were harvested as per following treatments: T_0 (No harvest/control), T_1 (50% harvest), T_2 (60% harvest), T_3 (70% harvest) and T_4 (80% harvest) with 5 replications and 5 treatments at each site (Table 1a). Initial population was recorded for each quadrate. 5 plants per quadrates were selected and harvested as per treatments. Observations were recorded in the month of May, November and March for emergence/presence of number of leaves.

Table 1a.Experimental Layout in Randomized Block Design

R_1	R_2	R_3	R_4	R_5
T_0	T_1	T_2	T_3	T_4
T_1	T_2	T_3	T_4	T_0
T_2	T_3	T_4	T_0	T_1
T_3	T_4	T_0	T_1	T_2
T_4	T_0	T_1	T_2	T_3

Experiments initiated in June, 2013:

The experiments related to harvesting intensities were laid out in Keochi forest division (Bilaspur), Sapalwa (Katghora), Lamani core area (Achankumar biosphere Reserve) in Chhattisgarh.

At each study site 16 quadrats of 10x10m (0.1 ha) area were laid out in randomized block design. Quadrats were located in forests having similar kind of management practices for leaves harvesting, protection, grazing etc. Each quadrat was sampled initially for Mahul populations before harvesting.

To standardize sustainable harvesting limits, leaves were harvested as per different treatments T_0 (No harvest/control), T_1 (40% harvest), T_2 (60% harvest) and T_3 (80% harvest) at each site with 4 replications and 4 treatments (Table 1b). Initial population was recorded for each quadrat. 5 plants per quadrat were selected and harvested according to treatment. Experiments were initiated in the month of June-July and observations were recorded in the month of July, October, December and February.Newly flushed leaves were labelled and counted in each quarter. The number of leaves flushed each quarter was calculated by subtracting the total number of leaves during the quarter.The total number of plants per blocks, leaves in initial stage, leaves remaining after harvesting at different intensities and % increase in leaves were recorded.

Table 1b.Experimental Layout in Randomized Block Design

R_1	R_2	R_3	R_4
T_0	T_3	T_1	T_2
T_1	T_2	T_3	T_0
T_2	T_1	T_0	T_3
T_3	T_0	T_2	T_1

Plant density/Regeneration

In order to assess plant density per hectare, the quadrat method was followed. About sixteen (16) quadrats of size 40 mX40 m. (0.16 ha) were selected in the forest area on random basis. All the plants of Mahul were enumerated within the quadrats. All the seedlings of Mahul (young recruits) were counted within the quadrat and recorded site wise.

Determination of quality of leaves

- **Leaf Area-** Leaf area was determined by randomly selecting 10 matured leaves in each season. Their length and width were measured with the help of a scale.
- **Estimation of Moisture% in leaves-**
  Moisture content of the fresh leaves was determined.The leaves were kept at 105±3^{o}C for 24 h. Triplicate determinations were made and the moisture content calculated on a wet basis from the difference between the wet and dry weight divided by the wet weight (AOAC, 1975).
- **Determination of strength –**The strength of leaves was determined by the estimation of force (N) required to tear the leaf longitudinally along the mid rib at three points.
- **Thickness of leaves-** Thickness of the leaves was determined with the help of vernier-caliper.

Statistical Analysis

The data collected was tabulated and analyzed with SPSS (version-14) package. The data recorded for various parameters during the study was subjected to Analysis of Variance and computation of significance of results.

RESULTS & DISCUSSION

Effect of harvesting on Leaf recruitment

- The leaves were harvested from selected plants as per experimental design. Average number of leaves observed after harvesting at different sites in the month of May (2012), November (2012) and March (2013) are presented in Table 2. Maximum number of leaves was found to be in control at all the sites followed by T_1 i.e. 50% harvest. There wasn't any significant difference among difference among T_0, T_1 and T_2 at Keochi (Marwahi) and Pali (Katghora). However, significant difference was observed among different treatments at Balco (Korba) in November, 2012.T_1 treatment was found to be best followed by T_2, T_3 and T_4.Significant difference was observed among different treatments at all the sites in November, 2012.Control was found to be best treatment at Keochi followed by T_1while at Pali control was followed by T_2 treatment i.e. 60% harvest and at Balco T_1 i.e. 50% harvest was found to be the best followed by control. There wasn't any significant difference among T_0, T_1 and T_2 at Keechi and Balco. However at Pali T_0 differed significantly with T_2 and T_3 in the month of March, 2013. Overall results revealed that at all the sites control performed best followed by T_1, T_2, T_3 and T_4.

- The initial number of leaves at each experimental site was recorded (Table-2a). Increase or decrease in leaves of *B.vahlii* wasobserved after harvesting at Keochi and Sapalwa (Pali) experimental sites in the month of July to Oct., 13, July to Dec., 13, July to Feb., 14, Oct. to Dec.,13 and Dec to Feb.,14 (Table-2b).It is envisaged from the data presented in Table-2c and Fig.6 that there is significantly sufficient regeneration potential in T_3 80% harvesting of leaves while treatments T_2,T_1 and T_0 showed declining trend in percent change in number of leaves. However, the difference in number of leaves was not statistically significant in T_0, $T_1$and T_2. The treatment T_3 (80% harvesting) had significantly high recruitment of leaves.

- Similar trend was observed in the protected area (Lamani Core Area, Achankmar Biosphere Reserve). Average percent increase or decrease of leaves observed after harvesting at Lamani, Bilaspur experimental site is presented in Table 2d and Fig.7.In control (No harvesting) percent change of leaf number was found to be negative. However, the difference in treatments T_0, T_1 and T_2 was non-significant.

Table 2 - Average no of leaves observed after harvesting in May, November and March, 2013

Location	Treatments (May,2012)					Treatments (November,2012)					Treatments (March,2013)				
	T0	T1	T2	T3	T4	T0	T1	T2	T3	T4	T0	T1	T2	T3	T4
Keochi	68.60± 9.53 [a]	64.44± 17.05[a]	54.88±8 .30 [a]	35.56± 6.06 [b]	23.64± 4.12 [b]	93.68± 10.86 [a]	48.00± 3.83 [b]	33.32± 4.65 [c]	25.52± 2.39 [d]	15.04± 0.99 [e]	66.76± 47.34 [a]	58.36± 20.40 [a]	56.76± 8.52 [a]	41.56± 12.04 [a]	45.4± 14.72 [a]
Balco	75.96± 12.72 [a]	45.04± 9.36 [b]	45.24±5 .06 [b]	41.56± 8.54 [b]	28.92± 5.91 [c]	98.36± 14.23 [a]	77.80± 2.28 [b]	71.72± 4.35 [b]	59.96± 5.67 [c]	35.2± 2.66 [d]	71.28± 43.07 [a, b]	90.16± 38.83 [a]	56.5± 19.03 [a ,b]	52.12± 10.28 [a, b]	41.04± 7.99 [b]
Pali	66.04± 7.62 [a]	57.68± 5.75 [a, b]	53.60±1 2.7 [a, b]	46.04± 6.15 [b]	31.68± 6.15 [c]	85.80± 63 [a]	60.16± 4.33 [b]	45.88± 8.62 [c]	36.64± 5.69 [d]	25.48± 5.04 [e]	76.20± 10.20 [a]	53.12± 2.30 [b]	47.8± 7.02 [b]	29.32± 8.40 [c]	18.96± 5.40 [d]

Data presented as mean±SD (n=5). Values denoted by different letters differ significantly at $p \leq 0.05$ within the row

Table 2a-Number of leaves (*Bauhinia vahlii* / Mahul Patta) per quadrat and per plant at three study site

Site	Treatments	July,13	Oct.,13	Dec.,13	Feb.,14
Keochi	**T0**	863±24.01	1244±38.30	1280±38.01	1127±39.03
		(43.1)	(62.2)	(64)	(56.35)
	T1	368±9.01	865±21.68	857±24.11	732±25.15
		(18.40)	(43.25)	(42.85)	(36.6)
	T2	333±10.42	990±35.47	1037±36.37	807±25.18
		(16.65)	(49.50)	(51.85)	(40.35)
	T3	199±5.23	1028±24.69	1084±24.68	1092±26.65
		(9.95)	(51.4)	(54.2)	(54.55)
	CD (P=0.05)	**8.72**	**18.93**	**19.50**	**18.33**
Sapalwa	**T0**	962±37.21	1432±58.52	1160±50	1193±50.78
		(48.1)	(71.6)	(58)	(59.65)
	T1	346±14.89	705±27.64	483±22.21	695±31.11
		(17.3)	(35.25)	(24.15)	(34.8)
	T2	313±12.17	925±30.73	774±28.19	983±30.69
		(15.56)	(46.25)	(38.7)	(49.15)
	T3	142±5.29	902±41.08	701±32.56	898±38.05
		(7.1)	(45.1)	(35.05)	(44.9)
	CD (P=0.05)	**13.09**	**25.58**	**21.56**	**23.87**
Lamani core area	**T0**	Experiment laid out in the month of Oct.,13	1382±37.65	1271±40.10	1069±33.65
			(69.1)	(63.55)	(53.45)
	T1		834±28.41	898±34.73	686±21.65
			(41.7)	(44.9)	(34.3)
	T2		567±16.48	642±22.95	533±18.45
			(28.35)	(32.1)	(26.65)
	T3		324±8.57	602±20.74	653±21.14
			(16.2)	(30.1)	(32.65)
	CD (P=0.05)		**15.69**	**18.44**	**15.15**

Data represent Mean±SD (n=20 plants).
Figure in parentheses are number of leaves per plant.

Table 2b: - Total no. of leaves of Mahul Patta *(B.vahlii)* increased with different harvesting limits in different months

Site	Types of measurements	Treatments	July-Oct.,13	Oct-Dec.,13	Dec-Feb.,14
Keochi	Total no.of leaves	**T0**	381±21.45	36±5.42	-153±12.66
			(19.05)	(1.80)	(-7.65)
	Total no.of leaves	**T1**	497±15.20	-8±7.36	-125±13.21
			(24.85)	(-0.4)	(-6.25)
	Total no.of leaves	**T2**	657±26.79	47±5.78	-230±13.88
			(32.85)	(2.35)	(-11.5)
	Total no.of leaves	**T3**	829±23.73	56±12.73	8±11.31
			(41.45)	(2.8)	(0.35)
	CD (p=0.05)		**13.75**	**5.17**	**7.04**
Site	**Types of measurements**	**Treatments**	**July-Oct.,13**	**Oct-Dec.,13**	**Dec-Feb.,14**
Sapalwa	Total no.of leaves	**T0**	470±41.03	-272±13.89	33±4.15
			(23.5)	(-13.6)	(1.65)
	Total no.of leaves	**T1**	359±17.22	-222±13.07	212±14.74
			(17.95)	(-11.1)	(10.65)
	Total no.of leaves	**T2**	612±23.90	-151±14.67	209±15.50
			(30.69)	(-7.55)	(10.45)
	Total no.of leaves	**T3**	760±37.72	-201±17.35	197±11.95
			(38)	(10.05)	(9.85)
	CD (P=0.05)		**19.54**	**9.19**	**7.68**
Site	**Types of measurements**	**Treatments**	**July-Oct.,13**	**Oct-Dec.,13**	**Dec-Feb.,14**
Lamani core area	Total no.of leaves	**T0**	Experiment laid out in the month of Oct.,13	-111±9.79	-202^{bcd}±13.11
				(-5.55)	(-10.1)
	Total no.of leaves	**T1**		64±16.42	-212±18.89
				(3.2)	(-10.6)
	Total no.of leaves	**T2**		75±10.12	-109±12.66
				(3.75)	(-5.45)
	Total no.of leaves	**T3**		278±13.28	51±14.11
				(13.9)	(2.55)
	CD (P=0.05)			**7.08**	**9.23**

Data represent Mean±SD (n=20 plants)
Figure in parentheses are number of leaves per plant.

Fig.no.6-Average% Increase leaves of *B. vahlii climbers in different season at two* study site of C.G

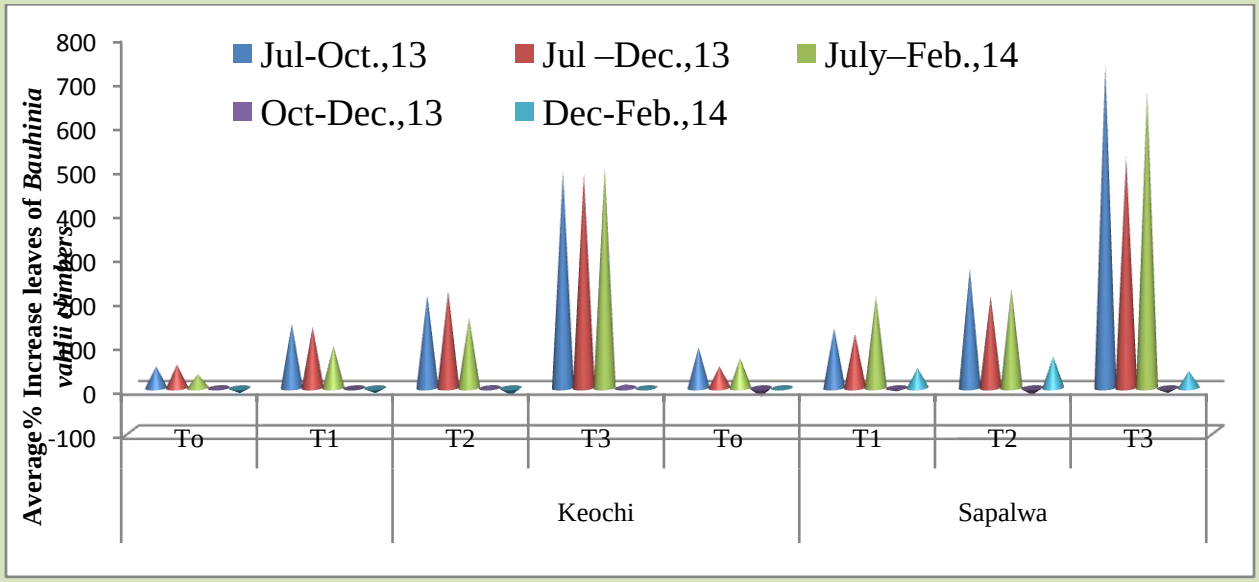


Table 2c-Average% Increase or Decrease of leaves of *B. vahlii* at different experimental sites.

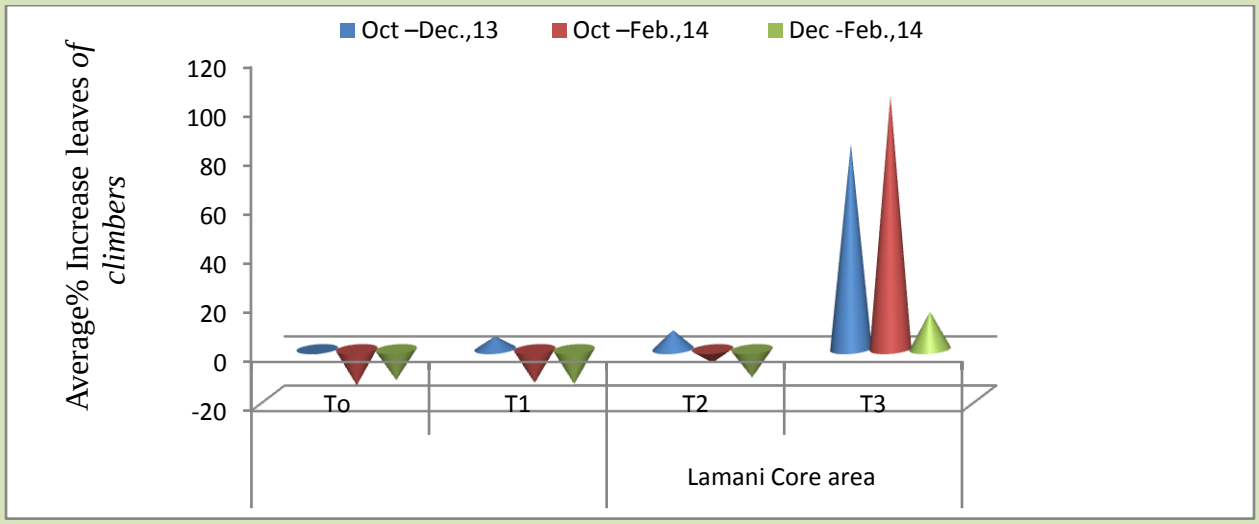
Site	Treat-ments	Average% Increase or Decrease no. of leaves observed after harvesting in different month					Mean
		Jul-Oct	Jul – Dec	July– March	Oct-Dec	Dec-March	
Keochi	To	49.49^{d}	53.68^{d}	31.21^{d}	4.45	-11.8	44.79^{d}±11.95
	T1	145.68^{c}	138.78^{c}	95.89^{bc}	-1.07	-11.64	126.78^{c}±26.97
	T2	210.85^{b}	220.13^{b}	160.30^{b}	5.17	-16.51	197.09^{b}±32.21
	T3	491.79^{a}	485.11^{a}	499.48^{a}	7.91	1.76	492.13^{a}±7.19
Sapalwa	To	92.24^{cd}	49.57^{cd}	68.38^{cd}	-19.85	2.16	70.06^{d}±21.38
	T1	135.7^{c}	123.33$^{b\,c}$	209.86^{bc}	-7.72	45.23	156.32^{c}±46.78
	T2	270.67^{b}	207.81^{bc}	226.82^{b}	-15.27	71.88	235.1^{b}±32.24
	T3	730.95^{a}	525.14^{a}	673.44^{a}	-11.51	38.52	634.18^{a}±106.19

Data presented as mean ±SD (n=5)

In column, means followed by common letters do not differ significantly at 5% level by Duncan's multiple range test (DMRT)

Parameters	Keochi	Sapalwa
(SE)	95.22	121.85
$(C.D.)_{0.05}$	201.87	258.32
$(C.D.)_{0.01}$	278.14	355.92
F cal.	3.11	3.20139
p-valve[1]	0.056009	0.0516409
F 5%	3.24	3.24
F 1%	5.29	5.29

Fig.7-%Increase of leaves of *B. vahlii* in different season at Lamani core area of C.G



- It is evident from the observation recorded that the leaf recruitment rates were lower during winter, with progressive increases into summer (Figure 6 & 7). These findings are congruent with those of Analuddin *et al.*(2009) and Kamruzzaman *et al.* (2012), reported similar seasonal trend in leaf recruitment in species *K. obovata*.Hardiwinoto *et al.* (1989) and Sharma *et al.*(2012) also observed in *B. gymnorhiza*, with the highest values in summer and the lowest in winter. The decreases in leaf production in winter may be caused by stresses induced by low temperatures.

Table 2c - % Increase or Decrease leaves of *Bauhinia vahlii* an experimental site

Site	Treat-ments	Average% Increase or Decrease no. of leaves per block			Mean
		Oct –Dec	Oct –Feb.	Dec –Feb.	
Lamani Core area	To	-2.045^{d}	-14.72^{bcd}	-12.58 ^{b}	-9.78^{b}
	T1	5.26^{bc}	-13.78^{bcd}	-14.19 ^{b}	-7.57^{b}
	T2	7.79^{bc}	-5.44^{bcd}	-11.51^{b}	-3.05^{b}
	T3	83.69^{a}	103.31^{a}	15.31^{a}	67.44^{a}

Data presented as mean ±SD (n=3).

In column, means followed by common letters do not differ significantly at 5% level by Duncan's multiple range test (DMRT)

Parameters	Value
(SE)	20
$(C.D.)_{0.05}$	46.1
$(C.D.)_{0.01}$	67.1
F cal.	6.92831
p-valve[1]	0.0129424
F 5%	4.07
F 1%	7.59

The data presented in Table 3 shows Mahul plant densities status at the three sites of Chhattisgarh state. The density of species (0.16 ha*)* was recorded in natural forests of experimental sites. The plant density was found to be changed in different seasons.The difference was observed in three different experimental plots. Maximum density was recorded in the month of October at Lamani core area (Achankmar Biosphere Reserve, Bilaspur)

Table -3 Densities of Plants at each experimental site in different month

Density of Plants each experimental site - plants/ quadrats				
Site	**JULY,13**	**OCT.,13**	**DEC.,13**	**MAR.,14**
Keochi	12.06	12.38	12.25	12.25
Sapalwa	5.31	5.25	5.00	5.00
Lamani	-	13.31	13.19	13.19

- It is evident from the observations recorded in different periods that the plant densities were found to be decreasing at all the sites. The change in densities might be due to the destructive harvesting or grazing or other anthropological pressures.

Table-2e Leaves collection from different treatments

Site	Treat-ments	July,13	Increased up to Oct ,13	Oct,13	Harvesting done in the month of Oct,13	Increased up to Dec ,13	Dec,13	Harvesting done in the month of Dec,13	Increased up to Feb ,14	March,14	Harvesting done in the month of Feb ,14
Keochi	T0	863±24.01	381±21.45	1244±38.30	NH	36±5.42	1280±38.01	NH	-153±12.66	1127±39.03	NH
		(43.15)	(19.05)	(62.2)		(1.80)	(64)		(-7.65)	(56.35)	
	T1	368±9.01	497±15.20	865±21.68	519±13	338±5.20	857±24.11	514±14.46	218±2.71	732±25.15	439±15.09
	T1	(18.40)	(24.85)	(43.25)	(25.95)	(16.9)	(42.85)	(25.71)	(10.9)	(36.6)	(21.95)
	T2	333±10.42	657±26.79	990±35.47	396±14.19	641±9.41	1037±36.37	414±14.54	393±14.43	807±25.18	322.8±10.07
	T2	(16.65)	(32.85)	(49.50)	(19.8)	(32.04)	(51.85)	(20.74)	(19.65)	(40.35)	(16.14)
	T3	199±5.23	829±23.73	1028±24.69	205±4.94	879±6.67	1084±24.68	216±4.94	868±7.54	1092±26.65	218.4±5.33
	T3	(9.95)	(41.45)	(51.4)	(10.25)	(43.95)	(54.2)	(10.84)	(43.4)	(54.6)	(10.94)
Sapalwa	T0	962±37.21	470±41.03	1432±58.52	NH	-272±13.89	1160±50	NH	33±4.15	1193±50.78	NH
	T0	(48.1)	(23.5)	(71.6)		-13.6±13.89	58±50		1.65±4.15	59.65±50.78	
	T1	346±14.89	359±17.22	705±27.64	423±16.58	60±3.04	483±22.21	290±13.32	405±15.44	695±31.11	417±18.67
	T1	(17.3)	17.95	35.25	21.15	3	24.15	14.49	20.25	34.8	20.85
	T2	313±12.17	612±23.90	925±30.73	370±12.29	404±10.91	774±28.19	309±11.27	674±14.61	983±30.69	393.2±12.28
	T2	15.56	30.69	46.25	18.5	20.2	38.7	15.45	33.7	49.15	19.66
	T3	142±5.29	760±37.72	902±41.08	180±8.23	521±12.52	701±32.56	141±6.51	757±20.12	898±38.05	179.6±7.61
	T3	7.1	38	45.1	9.02	26.05	35.05	7.05	37.85	44.9	8.99
Lamani core area	T0	Experiment laid out in the month of Oct.,13			1382±37.65	-111±9.79	1271±40.10	NH	-202±13.11	1069±33.65	NH
	T0				(69.1)	-5.55±9.79	(63.55)		-10.1±13.11	(53.4)5	
	T1				834±28.41	64±16.42	898±34.73	538±16.42	148±3.89	686±21.65	411±12.99
	T1				41.7	3.2	44.9	26.9	7.4	34.3	20.55
	T2				567±16.48	75±10.12	642±22.95	256±9.18	277±8.94	533±18.45	213±7.38
	T2				28.35	3.75	32.1	12.8	13.85	26.65	10.65
	T3				324±8.57	278±13.28	602±20.74	121±4.15	532±13.81	653±21.14	130.4±4.22
	T3				(16.2)	13.9	30.1	6.05	26.6	32.65	6.54

Data represent Mean±SD (n=20 plants).
Figure in parentheses are number of leaves per plant.
NH- No harvesting

Effect of harvesting on leaf Quality

- The data presented in Table-4a revealed that the size of leaves varied with season and harvesting intensities. The average leaf size was more in other seasons as compared to winter months. The size of leaves was found to be reduced, length and width varied 12.06-32.6 cm and 9.36-31.6 cm, respectively, in 80% harvesting. The difference was non-significant in T_0, T_1 and T_2 in comparison to T_3 -80% harvesting (Table-4a).

- The leaves collected in October was found to be larger in size in comparison to harvesting in other periods. The size of leaves in T_3 treatment was showed maximum reduction December and February in comparison other treatments. It is revealed that newly recruited leaves grow slowly due to low temperature and water availability in 80% harvesting followed by T_2, $T_1$and T_0 treatments.The difference in temperature and air vapour pressure deficit (VPD) between summer and winter contributed to the present dynamics of foliage patterns. Only, few field experiments have investigated the effects of environmental temperate and boreal forest biomes, trees of most species have leaf phonologies and life spans (if deciduous) with seasonal patterns and supports the findings. Williams *et al.* (1997); Shukla and Ramakrishnan (1984) also reported similar linkage of tree species phenology with seasonality occurs in many, but not all, species in tropical forests and woodlands.

Table -4 a Quality-Size of leaves in different harvesting intensities

		To (con)		T1(40%H)		T2(60%H)		T3(80%H)		CD (p=0.05)
		L(cm)	W(cm)	L(cm)	W(cm)	L(cm)	W(cm)	L(cm)	W(cm)	
Keochi	July	32.6 ±3.12	28.6 ±4.05	30.4 ±3.53	28.5 ±2.45	30.9 ±4.11	28.0 ±4.18	32.6 ±3.35	31.6 ±5.02	NS 1.34(W)
	Oct.	35.6 ±5.12	30.6 ±4.35	31.45 ±3.31	29.2 ±4.05	31.87 ±2.08	28.4 ±2.11	30.50 ±3.63	24.6 ±2.31	3.06 (L) 4.13 (W)
	Dec.	29.61 ±4.78	25.64 ±4.99	29.64 ±4.99	26.24 ±4.99	28.26 ±2.15	25.37 ±3.03	22.64 ±4.99	19.61 ±4.78	4.16 (L) 3.13 (W)
	Feb.	25.9 ±3.80	21.9 ±1.13	28.61 ±4.78	25.06 ±4.24	27.24 ±2.79	23.65 ±3.58	20.33 ±5.82	17.86 ±5.66	4.20 (L) 3.03 (W)
CD (p=0.05)		4.16	3.51	5.56	2.14	1.65	2.09	3.67	2.45	
Sapalwa	July	33.6 ±3.63	29.6 ±2.31	25.40 ±1.55	19.2 ±3.47	22.3 ±1.50	24.50 ±2.84	18.2 ±3.47	13.96 ±5.89	3.16 (L) 1.04 (W)
	Oct.	33.4 ±3.53	29.7 ±2.36	22.4 ±1.47	21.5 ±3.50	21.6 ±1.77	20.0 ±3.02	17.5 ±3.50	14.51 ±1.41	2.98(L) 2.52(W)
	Dec.	29.51 ±4.85	25.55 ±5.05	22.54 ±3.35	21.32 ±2.36	22.56 ±2.13	20.50 ±3.36	15.50 ±2.36	11.48 ±3.09	3.89(L) 5.02(W)
	Feb.	28.64 ±5.75	25.02 ±5.44	16.86 ±5.66	13.96 ±5.89	15.26 ±4.34	14.4 ±4.56	14.96 ±5.89	10.36 ±3.25	2.14(L) 1.98(W)
CD (p=0.05)		3.98	3.57	2.33	2.47	1.90	2.84	3.57	3.98	
Lamani core area	Oct,13	29.26 ±0.35	25.67 ±0.42	28.50 ±0.92	22.76 ±1.77	27.51 ±1.41	24.50 ±2.41	28.89 ±0.42	24.5 ±0.35	0.21(L) 0.89(W)
	Dec,13	31.95 ±4.11	28.08 ±4.18	27.86 ±5.17	21.83 ±5.64	23.50 ±4.09	20.80 ±5.64	15.51 ±5.15	11.48 ±3.09	4.98(L) 2.87(W)
	Feb. 14	27.86 ±5.17	24.42 ±4.97	24.91 ±3.87	21.8 ±4.92	22.54 ±6.07	19.34 ±6.07	12.06 ±4.62	9.36 ±3.25	6.90(L) 4.32 (W)
CD ((p=0.05)		3.51	3.45	2.83	3.76	3.45	3.51	2.03	2.67	

Data presented as mean ±SD (n=10)

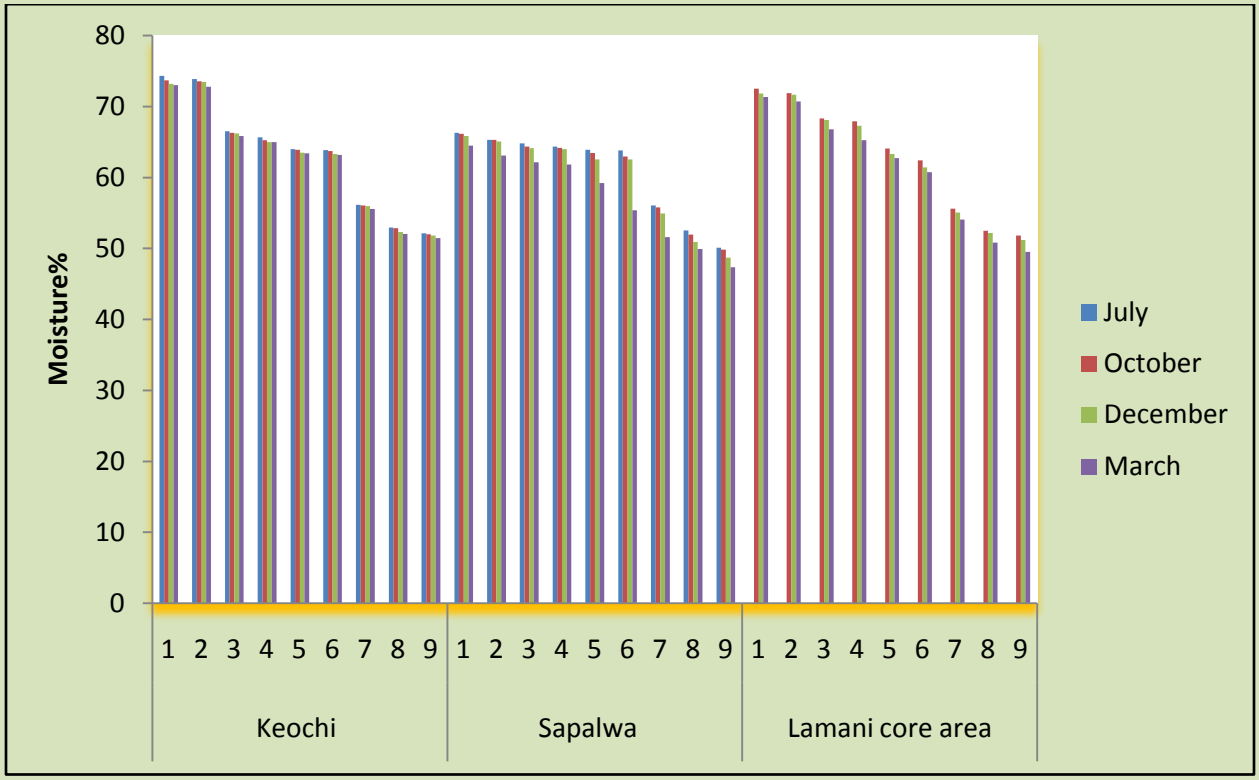
- It is clear from the observations recorded that the leaf growth pattern varied with season. Size of the leaves found to be reduced significantly in winter i.e. December and February in T_3 in comparison other treatments.
- The data depicted in the Table 4b &Fig.8 indicates moisture% of different maturity leaves in different collection seasons/periods. The moisture varied 49.07-57.24% while 52-74.33% in different maturity leaves. The matured leaves had less moisture.

Table 4b: - Moisture percentage of Mahul Patta (*B. vahlii*) matured leaves

Site	Months	T0 (Control)	T1 (40%H)	T2 (60%H)	T3 (80%H)
Keochi	July,13	51.61±0.18	53.22±2.48	54.25±2.08	55.27±0.48
	Oct.,13	54±1.37	52.11±3.05	52.45±1.05	53.61±3.48
	Dec.,13	52.83±2.19	52.05±0.05	52.30±2.05	53.33±1.84
	Mar.,14	52.47±0.48	51.90±1.17	52.21±1.27	52.95±2.27
Sapalwa	July,13	50.10±2.36	50.53±3.16	52.34±3.16	54.0±1.45
	Oct.,13	57.19±0.48	49.95±2.71	50.50±2.76	52.50±2.67
	Dec.,13	57.70±1.11	49.05±3.15	50.25±4.15	52.45±5.45
	Mar.,14	57.22±0.48	48.05±4.82	49.07±4.02	50.50±4.50
Lamani core area	Oct.,13	54.83±1.29	52.54±4.29	53.04±1.29	54.65±1.94
	Dec.,13	53.17±4.74	51.50±0.74	52.37±2.74	53.76±1.75
	Mar.,14	53.32±0.84	50.85±0.81	51.69±0.33	52.30±1.33
	June,14	51.32±3.16	49.80±1.16	50.12±0.26	49.01±2.16

Data presented as mean ±SD (n=3)

Fig.8– Moisture % of *B. vahlii* different age group leaves in different months at three study site



Effect of Harvesting on strength of leaves

- The strength of leaf was calculated by measuring the force (N) needed to tear a leaf. It was observed that harvesting time had a significant effect on strength of leaves (Table 4c). The leaf samples collected in summer season showed more strength (2.47-2.53N) from different sites followed in spring (2.23-225 N). The strength of the leaves was found to be decreased after rainy seasons (2.13-2.30 N).

Table 4c Strength of *B.vahlii* leaves in different harvesting time

	Strength (Newton)				
Sites	**July**	**Oct.**	**Dec.**	**Mar.**	**CD(p=0.05)**
Keochi	2.47	2.18	2.19	2.25	0.21
Sapalwa	2.53	2.13	NR	NR	
Lamani core area	2.49	2.30	2.31	2.23	0.09
Shader (Katni)	2.52	2.23	2.13	2.29	0.14

Data presented as mean ±SD (n=10)

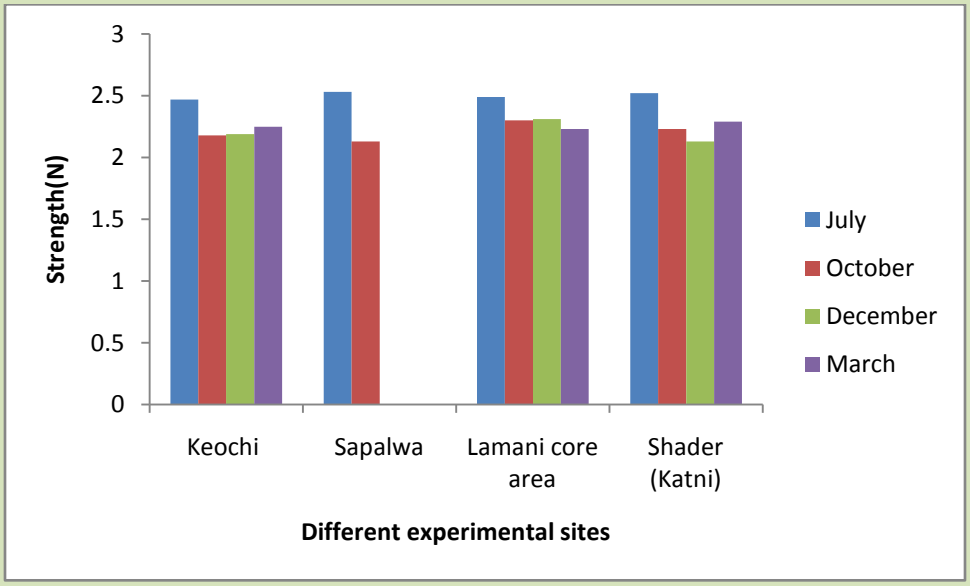


Fig.9 Variation in strength of leaves collected in different duration

The strength of *Butea monosperma* (Palas) and *Diospyros melanoxylon* (Tendu) was recorded 2.45N and 2.78 which were found to be similar or better than Mahul leaves (Table-4d).

Table 4d: Strength (based on load bearing capacity of leaf in Newtons) of *B.vahlii* mature leaves and other species which are suitable for Dona making species

Name of species	Upper Portion	Middle Portion	Lower Portion
	Newton	Newton	Newton
Buteamonosperma	2.55±0.10	2.45±0.11	2.37±0.17
Diospyrosmelanoxylon	2.81±0.19	2.78±0.19	2.69±0.18
Bauhinia vahlii (mature)	2.36±0.10	2.23±0.15	1.75±0.06
CD (p=0.05)	0.13	0.14	0.14

Mean of 10 observation± SD

Tendu and Palas are also important species, available abundantly in tropical forests. The strength of these leaves are also comparable with Mahul leaves.

The leaves attained full maturity in 8-9 weeks. The leaf growth pattern i.e. leaf colour, texture, size, moisture and thickness are depicted in Table-5, Fig.10,11&12. The thickness and moisture% of the leaves reduced with the age.

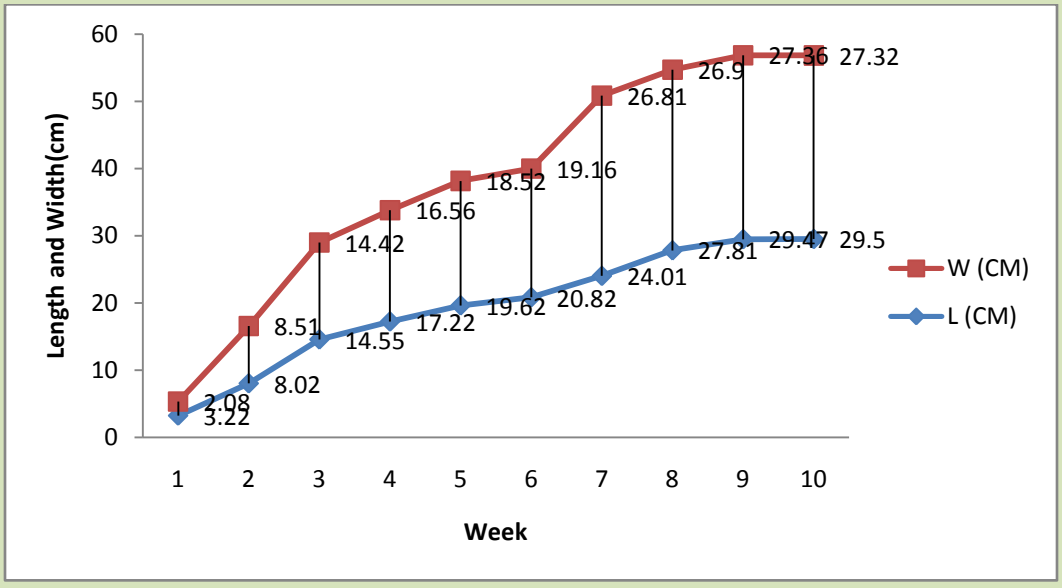


Fig. 10 Variation in size in different maturity leaves

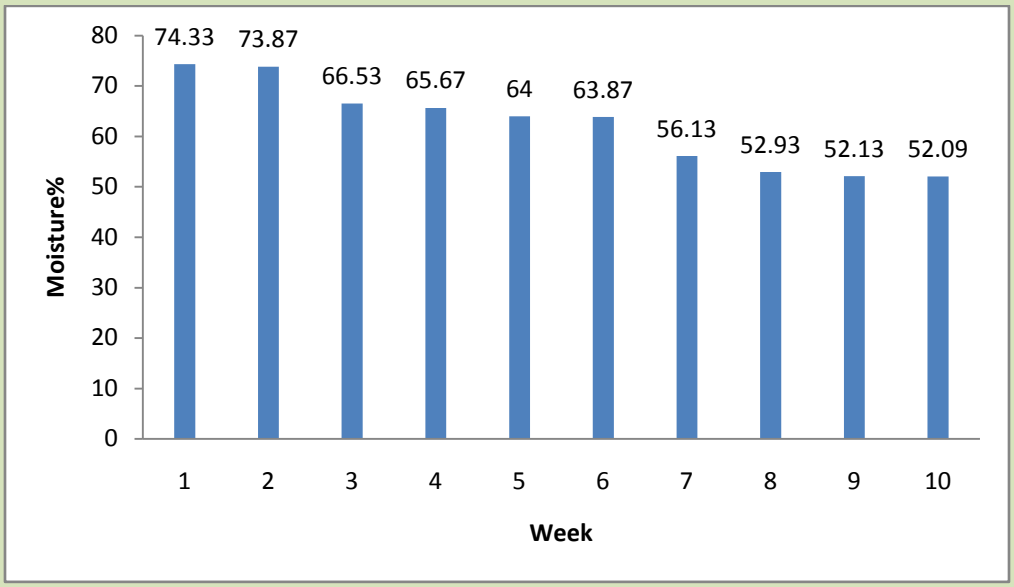


Fig.11 Variation in moisture % in different maturity leaves

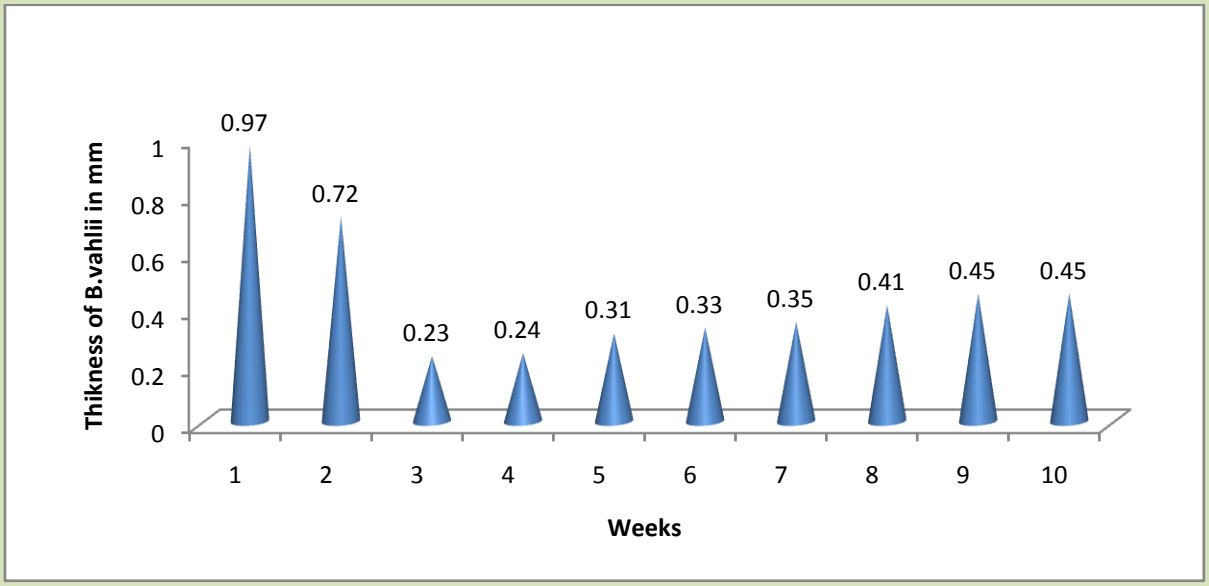


Fig. 12 Thickness of Mahul Patta different age group leaves

Table -7f: Quality of different age groups Mahul patta leaves

Sample Name	Average size of leaves of Mahul Patta		Leaf Colour / Leaf harvested by local people		Insect/fungal attack	Texture of Mahul leaf
	L (cm)	W (cm)	Colour/Opening condition of leaf	Leaf Harvested by local People		
1 week	3.22±1.30	2.08±0.85	Light Pink -Closed	X	Not infested	New ,Fine, Smooth, lathery
2 week	8.02±1.64	8.51±2.93	Dark Pink -Closed	X	,,	Fine, Smooth , lathery
3 week	14.55±1.95	14.42±3.57	Light Green/Open	X	,,	Fine, Smooth
4 week	17.22±1.61	16.56±1.70	Light Green/ Open	X	,,	Fine, Smooth
5 week	19.62±1.05	18.52±1.71	Dark Green / Open	X	,,	Smooth ,
6 week	20.82±1.03	19.16±1.68	Dark Green / Open	X	,,	Smooth ,
7 week	24.01±1.81	26.81±1.55	Dark Green / Open	√	,,	Mature
8 week	27.81±2.11	26.9±1.85	Dark Green/ Open	√	Infested/damaged	Mature
9 week	29.47±3.56	27.36±1.56	Greenish to Yellowish /Open	√	Infested/damaged	Mature

X-not harvested, √-Harvested

Flower and Fruiting status

The flowering was not observed in the plants of all treatments at all the sites (Table 6a).

The species can grow even up to the top canopy in natural forests. However, at the study sites, flowering was recorded in climbers of 8.5 to 16.5 meter height only.

Similar observations were also recorded at Shader (Katni) in Madhya Pradesh. Flowering and fruiting were observed only in matured climbers of 20 to 30 m height (Table 6b),which were found in few or almost absent in the study sites of Chhattisgarh as well in Madhya Pradesh, limiting the studies finding of the relationships with harvesting .

As the people of the area has large dependency on this species. The status of this species has been severely impacted due to destructive harvesting. This may also has also affect the vigour of the species and negative impact on flowering and fruiting in this species.

New plants of this species regenerate through seeds only, which were found to be scanty in the area and fairy long time interval (10-12 months) between pod formation and maturation does not ensure adequate supply of seeds for regeneration in natural conditions (Upreti and Dher, 1996) and ultimately impacted the natural regeneration of the species. Further, the seeds are collected by local tribal people and eaten both raw and fried. It is evident from the density status of species recorded in different seasons at different experimental sites. The plant density was found to have decreased at all sites.

Mishra and Teki (2007) also observed extremely poor regeneration of *B. vahlii* plant in the natural forests in three districts of Orissa. They reported only 1, 2.62 and 2.50seedlings per hectare in Rayagada, Malkangiri and Koraput districts of Orissa.

Intensive and destructive harvesting has lead to the extinction of several species. In many cases the unsustainable extraction has drastically reduced the population to the below critical level.Prasad and Bhatnagar (1991) also reported the impact of unsustainable harvesting of some NTFPs viz.,lopping of beedi leaves *(Diospyros melanoxylon),* burning of forest floor to facilitate collection of Mahua (*Madhuca latifolia*) flowers during summer months, extraction of wild .honey by felling whole trees etc. in central India. Destructive tapping by making blaze on tree trunk repeatedly every year killed or damaged a large number of gum Karaya trees (*Sterculia urens*) in the natural forests of M.P and Orissa (Mishra,2004).

Table 6a-Flowering /fruiting status in *B. vahlii* climber in different treatments

Site name	Treatments	Average Height (m)	Total no. plants	March,2014		April,2014		June ,2014		July ,2014	
				Flowering	Fruiting	Flowering	Fruiting	Flowering	Fruiting	Flowering	Fruiting
Keochi	T0 (Control)	1.94	20	A	A	A	A	A	A	A	A
	T1(40%)	1.79	20	A	A	A	A	A	A	A	A
	T2(60%)	1.58	20	A	A	A	A	A	A	A	A
	T3(80%)	2.37	20	A	A	A	A	A	A	A	A
	Climber (Flowering observed)	10.5		A	A	**P**	A	**P**	A	**P**	A
Lamani Core area	T0 (Control)	2.04	20	A	A	A	A	A	A	A	A
	T1(40%)	1.99	20	A	A	A	A	A	A	A	A
	T2(60%)	2.04	20	A	A	A	A	A	A	A	A
	T3(80%)	2.07	20	A	A	A	A	A	A	A	A
	Climber (Flowering observed)	16.5		A	A	**P**	A	**P**	A	**P**	A
Sapalwa	T0 (Control)	3.01	20	A	A	A	A	A	A	A	A
	T1(40%)	2.53	20	A	A	A	A	A	A	A	A
	T2(60%)	2.63	20	A	A	A	A	A	A	A	A
	T3(80%)	2.45	20	A	A	A	A	A	A	A	A
	Climber (Flowering observed)	8.5		A	A	**P**	A	**P**	A	**P**	A

A- absent, P-present

Table 6b-Flowering /fruiting status in *B.vahlii* climber at Shader (Katni), Madhya Pradesh

Sahdar (Katni) / Months	Quadrat/Climbers (10x10m, 15quadrat)	Climbers of *B.vahlii* in each quadrat														
		P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12	P13	P14	P15
	Height (m)	5.7	5.0	5.0	5.09	8.0	4.8	8.0	9.0	4.5	3	25	20	20	30	30
	Collar diameter (cm)	4.93	1.75	6.62	4.77	12.09	10.19	13.68	9.23	10.19	6.37	20.05	17.18	15.28	21.32	19.74
July,2014	Flowering	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P
	Fruiting	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P
	Colour of flower	-	-	-	-	-	-	-	-	-	-	White Colour appearance				
	No. of pods	-	-	-	-	-	-	-	-	-	-	4	6	9	10	12
	Colour of pods	-	-	-	-	-	-	-	-	-	-	Greenish to Brown Colour				
August,2014	Flowering	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	Fruiting	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P
	No. of pods	-	-	-	-	-	-	-	-	-	-	4	6	9	10	12
	Colour of pods	-	-	-	-	-	-	-	-	-	-	Brown Colour appearance				
September,2014	Flowering	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	Fruiting	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P
	No. of pods	-	-	-	-	-	-	-	-	-	-	4	6	9	10	12
	Colour of pods	-	-	-	-	-	-	-	-	-	-	Brown Colour appearance				
October,2014	Flowering	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P
	Fruiting	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P
	Colour of pods	-	-	-	-	-	-	-	-	-	-	Brown Colour appearance				
November,2014	Flowering	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
	Fruiting	A	A	A	A	A	A	A	A	A	A	P	P	P	P	P
	Colour of pods											Brown Colour appearance				

A- absent,P-present (based on weekly observations in months)

Table-6c **Flowering /fruiting status in *B.vahlii* climber at different experimental sites (surveyed approx. 6 hectare area in June,2015)**						
S.No. of Climber	**Keochi (Bilaspur)**		**Lamani core area(Bilaspur)**		**Sapalwa (Katghora)**	
	Collar diameter (cm)	**Height (m)**	**Collar diameter (cm)**	**Height (m)**	**Collar diameter (cm)**	**Height (m)**
1.	8.27	10	18.46	18	15.27	20
2.	12.09	06	15.59	15	8.27	08
3.	10.19	06	13.37	15	17.83	32
4.	8.27	08	14.96	22	15.59	26
5.	11.46	08	21.01	35	14.00	26
6.	8.91	08	11.14	20	14.32	20
7.	12.09	12	15.27	15	7.95	15
8.	14.64	14	11.46	15	8.59	18
9.	13.37	10	8.92	15	18.46	30
10.	11.46	08	17.83	28	14.64	25
11.	8.91	08	14.64	25	-	-
12.	10.82	11	10.19	12	-	-
13.	12.09	10	12.09	23	-	-
14.	16.56	18	15.27	25	-	-
15.	10.19	08	9.55	20	-	-
16.	17.83	10	-	-	-	-
17.	10.19	06	-	-	-	-
18.	13.37	09	-	-	-	-

CONCLUSION

Bauhinia vahlii is an important NTFP of economic value in the tribal belt of Central India.

The study revealed that harvesting intensities of *B.vahlii* affect number of leaves as well as quality.

Based on three year studies (2011-2014) at six different sites in Chhattisgarh, it was concluded that harvesting intensities, 50-60% was found superior for getting quality as well as progressive recruitment of leaves in natural forest areas. It is envisaged from the results that with increase in harvesting percentage (80%), size and number of matured leaves were reduced drastically. The leaves collected in the month of June-July having greater strength in comparison to the collection in winter seasons.

The flowering age of the *B. vahlii* is not reported in the literature. Exhaustive survey of experimental sites in Chhattisgarh and Shader, Katni Division, Madhya Pradesh and interaction with local collectors, revealed that flowering and fruiting occurred only in matured climbers. Further, the regeneration is also affected due to long time interval (10-12 months) between pod formation and maturation and collection of seeds for edible purposes. Therefore, to establish impact of harvesting on flowering, continuous observations are needed.

Density and regeneration of *B. vahlii* was extremely poor in experimental sites i.e. Keochi, Sapalwa and Lamani (Bilaspur) in Chhattisgarh.

The leaves of Mahul are available for 10 months. To collect more leaves from plants, collectors sometime cut the main trunk (and or branches) of the climber and pluck the whole leaves. Due to destructive harvesting of the leaves and bark of this species, a declining trend has been observed in natural forest areas.

It is suggested that harvesting should be restricted to twice in a year without damaging the climbers. The harvesters should be encouraged to pluck leaves with the help of bamboo stick

(as the climber is very long) attached with plucking device or sickle or hand plucking wherever plant height is less and leaves are approachable. The collection of Mahul seeds should be banned to increase regeneration of species.

These problems can also be addressed by educating, imparting appropriate training to the local harvesters as well as Dona manufacturers. Some plants should be left un-harvested for few years to improve natural regeneration under wild environment.

The utilization of other leaves i.e. *Butea monosperma* and *Diospyros melanoxylon* having better strength than Mahul Patta may also be encouraged in Dona or plates making to avoid excessive or destructive harvesting of Mahul Patta.

FINANCIAL ACHIEVEMENT:

Expenditure Statement (2011-14)				
S.No.	**Head**	**Amount received (Rs. in lakh)**	**Expenditure (TFRI, Jabalpur)**	**Balance (Rs. in lakh)**
1	**2**	**3**	**4**	**5**
1	JRF	9.34	2.87	
2	M&S		1.37	
3	Wages		0.65	
4	Travel		2.59	
5	Contingency		0.34	
6	Institutional charges		1.22	
	Total (Rs. in lakh)	**9.34**	**9.04**	**0.30**

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Newly recruited leaves in Mahul Patta climbers

Harvesting of Mahul Patta

Mature climbers of *B. vahlii*

Flowering inmature climbers of *B.vahlii*