PROGRESS REPORT OF THE PROJECT

Assessment of Guggul Germplasm for Studying Population Density, Diversity, Female-Male Plant's Ratio for *In Situ* and *Ex Situ* Conservation in Rajasthan

(Reporting Period Four Years - 2010-14)

Submitted to

State Forest Department

Of Rajasthan



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INDEX

C	Contents					
		Part I: Physical Progress				
1.	Proj	ject Brief	2			
2.	Intr	oduction	2			
3.	Obj	ectives defined	3			
4.	Proj	ject Progress	3			
	I.	Survey work	4			
	II.	Germplasm collection	25			
	III.	Study on flowering & fruiting	28			
	IV.	Seed studies	29			
	V.	Macropropagation	33			
	VI.	Genetic Characterization (DNA Marker studies)	37			
5.	Obj	ectives met	43			
		Part II: Finanical Progress				
Bı	udget	t utilization	44			
D	etails	of project staff recruited	44			
	A. I	Utilization Certificate (Performa A)	45			
	B. /	Annual Statement of Accounts (Performa B)	46			
	C. (Certificate of non receipt of Funds	47			
A	nnex	ure A (Guidelines for seed germination)	48			
A	nnex	ure B (Guidelines for vegetative propagation)	52			

Part I: Physical Progress

1. Project Brief

a)	File No.	7.16					
b)	Date of Sanction	12.04.2010					
c)	Duration & Budget	3 Years (One year extended), Rs 17.00 Lakhs					
d)	Name of PI	Dr. U. K. Tomar, Scientist F					
e)	Title of Project	Assessment of Guggul Germplasm for Studying Population Density, Diversity, Female-Male Plant's Ratio for <i>In Situ</i> and <i>Ex Situ</i> Conservation in Rajasthan					

Project was sanctioned in the end of March 2010. Budget Rs 7.00 lakhs was released for the year 2010-11 to AFRI by SFD Rajasthan which was received in the 2nd week of April. Second Installment of Rs 4.62 lakhs for year 2011-12 and 3rd installment of Rs 3.34 lakhs was released in 21 Sept., 2013. Final and last installment of Rs 2.04 lakhs was received in last week of Dec. 2013. The project was completed in March 2014. Detailed project report is as follows:

2. Introduction

Commiphora wightii has become endangered possibly because of its slow growing nature, poor seed setting and seed germination, lack of cultivation, excessive harvesting for religious, domestic purposes (as fuel by rural people) and unscientific tapping for its gum resin by the pharmaceutical industries. Because of these reasons, the population of this plant has reduced drastically and at present this plant has been incorporated in Data Deficient category of IUCN's Red Data list.

This species is dioecious and produce a male plant and a female plant. Guggul has adopted apomixis mechanism due to extinction of male plants in the population. Major portion of female plants are producing seeds without fertilization and producing copies of same genotypes. This situation will definitely reduce the gene pool of this valuable medicinal plant resource. Nevertheless, this hypothesis based on one publication need to be verified with more authentic tools for larger germplasm. Therefore, it was necessary to assess the population density and collection of germplasm from different sites with keeping their identity and GPS locations as germplasm conservation strategy. Based on this, present project was prepared to carry out survey in the Rajasthan state for studying population density, diversity, identify CPPs for *in situ* and *ex situ* conservation in Rajasthan state. Flowering, Fruiting and seed germination and vegetative propagation studies to prepare guidelines to Stakeholders. Some work on Isozyme and DNA marker has also been carried out to assess the genetic diversity existing in natural populations at different forest ranges of Rajasthan. Progenies of CPPs collected from six different locations were also decided to study for understanding their breeding behaviour.

3. Objectives defined

- Survey and study of natural guggul populations in Rajasthan State with emphasis on population density and sex ratios using sampling procedures and its documentation (Data will be collected, GPS locations will be recorded and documented).
- II. Identification of female Candidate Plus Plants (CPPs) on the basis of high viable seed yield and rare male and andromonoecious plants. Seed parameter studies of selected CPPs for identification of CPPs for high seed germination ability.
- III. Collection of identified female CPPs and rare male and andromonoecious plants for *ex situ* conservation and propagation.
- IV. Studies on macropropagation and nursery practices for selected germplasm.

V. Genetic characterization of progenies and germplasm and their ex situ conservation.
Objective V were added in fourth year vide Director, AFRI's letter No. 2737 dated 22 Jan.
2014 as it was felt ncessary before *ex situ* conservation of collected germplasm.

4. Project Progress:

Procurement of equipments and recruitment of project staff were initiated immediately after the sanction of project. Base information was collected from State Forest Department, Rajasthan before initiating the survey work as per MOU signed between AFRI and SFD Rajasthan. Based on the information received from SFD Rajasthan, a map of guggul density is generated. In this map black spots are showing highest density (>100 plants per ha), followed by green spots (51-100 plants per ha), blue (6-50 plants per ha) and minimum red (up to 5 plants per ha).



Figure 1: A map of guggul density is generated from the information received from forest department of Rajasthan.

According to the objective, work has been initiated on four research areas initially and fifth research area is added in fourth year. These five research areas are as following:

- Survey work: Collected data from field sites by using sampling procedures and GPS location and also collected information other than the information provided by SFD Rajasthan. These data were used to calculate population density and variance using statistical tools.
- II. Germplasm Collection: From each site, CPPs were indentified on the basis of growth parameters and vegetative stem cuttings were collected and raised in vegetative propagation complex.
- III. Seed Studies: Seeds were collected to study the phenological aspects and its annual pattern. Seeds were collected from different sources along with the identity of genotypes. These seeds were raised under *in vitro* conditions for further studies.
- IV. Vegetative Propagation: Stem cuttings were collected from different sources and in different seasons and raised in mist polyhouse for rooting. Methods of earlier described scientists were used.

V. Genetic Characterization: All the germplasm collected vegetatively (stem cuttings) and through seeds were raised for *ex situ* conservation and subjected to genetic characterization to study the overall genetic diversity in Rajasthan State and Breeding behavior through progeny study.

Details of the work carried out on these three aspects are described in following paragraphs:

I) Survey work:

On the basis of above information received from SFD, survey was initiated, so far 33 districts of Rajasthan namely, Ajmer, Banswara, Baran, Barmer, Bharatpur, Bhilwara, Bikaner, Bundi, Chittorgarh, Churu, Dungarpur, Hanumangarh, Jaipur, Jaisalmer, Jalore, Jhalawar, Jhunjhunu, Jodhpur, Karauli, Kota, Nagaur, Pali, Pratapgarh, Rajsamand, Sawai Madhopur, Sikar, Sirohi, Sri Ganganagar and Udaipur are covered except two National Parks . A total of 2660 sample plots, 141 sites in 33 districts were surveyed covering 10294 hectare where Guggul occurrence has been recorded.

GPS data were collected on altitude, longitude and latitude of each sample plot. GPS sample plots locations and colour codes for population densities viz. white (average population density below 1 plant per plot), blue (1-3 plants per plot), green (4 to 6 plants per plot), (dark green 7 to 9 plants per plot), red (10-14 plants per plot) and dark red (15-35 plants per plot) were loaded on Rajasthan map by using software. The Rajasthan state map of guggul plants density was generated with the data collected by AFRI (Figure 2 A & B). Figure 1 A is showing all the locations visited by AFRI Staff team and Figure 2 B is showing actual density of guggul plants in different forest areas of Rajasthan.

It was also observed that altitudinal variation also influence the population density of guggul plants. Therefore, data were also arranged in different altitude classes (Table 1). Maximum average density (3.6 plants /plot or about 40 plants per ha) was recorded in a class of 301-350 m AMSL (Figure 3). Studies are still needed to understand other factors like human population density, climatic factors etc. near these guggul growing areas.



Figure 2: A; Sample plot locations in the areas of Rajasthan State and B; Population density spots with colour codes in Rajasthan State, where Guggul plants are naturally occurring.



Table 1: Sixteen altitude classes developed to study altitudinal factor on guggul plants density.

Figure 3: Guggul plants average populatition density per plot against altitude classes.

Present status of Forest Range areas of each Rajasthan District having guggul plants is given in following paragraphs (except Sariska Sanctuary Alwar):

1. Ajmer – Data were collected from three locations where the guggul plants were available. These three sites of Ajmer are Badkochra, Kotda and Taragarh. The average guggul population density of all three sites was found around 36 plants per hectare. The site wise population density is given in Table 2.

Table 2. Status of Ajmer district

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Badkochra	71	84	25°52.345'	074°15.418'	11
2	Kotda	50	6	26°01.771'	074°11.557'	9
3	Taragarh	50	14	25°51.826'	074°08.986'	12

The other major associated plant species found were *Euphorbia caducifolia, Boswellia* serrata and Acacia senegal.





Figure 4. Badkochra- This site exhibits guggul population in 71 hectare area. Guggul population density is 84 plants per hectare.

Figure 5. Kotda- This site has guggul population in 50 hectare area. Guggul population density is 6 plants per hectare.



Figure 6. Taragarh- Guggul population density recorded is around 14 plants per hectare in total area of 50 hectare.

2. Jodhpur – In this district total 7 sites were visited. The average guggul population density of all these sites was around 35 plants per hectare. The sitewise population density of these 7 sites is given in Table 3.

S. No.	Range/Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Mandore (Badabhakhar)	60	106	26°17.975'	072°58.174'	13
2	Mandore (Arna)	150	35	26°17.481'	072°53.900'	30
3	Mandore (Barli)	60	47	26°18.584'	072°54.748'	11
4	Mewasa	200	17	26°41.138'	073°03.542'	18
5	Mandore (Daizar)	90	21	26°24.262'	073°02.275'	18
6	Mandore (Beriganga)	200	22	26°22.934'	073°03.500'	36
7	Osiyan	500	Nil	26°40.522'	073°03.685'	15

Table 3. Status of Jodhpur district

The other major associated plant species with guggul were *Prosopis cineraria, Prosopis juliflora, Ziziphus numularia, Euphorbia caducifolia* and *Acacia senegal*.





Figure 7. Badabhakar - This site covers guggul population in 60 hectare area and population density of 106 plants per hectare.

Figure 8. Arna - This site is protected by SFD in 150 ha area. Above picture shows exuding gum from the injured part of the plant.



Figure 9. Barli - This site is also protected by Forest department in 60 hectare area.Immature seeds were observed.



Figure 10. Mewasa - This site has guggul population in 200 hectare area. Guggul population density is 17 plants per hectare.





Figure 11. Daizar - This site exhibits guggul population in 90 hectare area and population density is 21 plants per hectare.

Figure 12. Beriganga - This site has guggul population in 200 hectare area and guggul population density is 22 plants per hectare.

3. Pali- The average guggul population density was found around 21 plants per hectare of all the 7 sites visited in this district. Maximum density (49 plants/ha) was recorded in Sumerpur forest block and minimum (below 2 plants/ha) was in Bali forest blocks. The site wise population density of this district is given in Table 4.

S.No.	Range/ Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Sendra (chang)	150	11	26°06.976'	074°14.415'	28
2	Sendra (Borwad)	100	4	26°03.359'	074°11.243'	18
3	Bali (Nana)	50	Nil	24°55.379'	073°08.397'	9
4	Bali (Kumbhsagar)	100	2	24°54.723'	073°09.188'	24
5	Sumerpur (Nimboka nath)	100	19	25°96.240'	073°11.683'	25
6	Sumerpur (Kalabhakar)	100	37	25°15.130'	073°07.385'	21
7	Sumerpur (Jawaai bandh)	100	49	25°06.013'	073°09.997'	25

Table 4. Status of Pali district

Major plant species namely *Acacia tortilis*, *Prosopis cineraria*, *Prosopis juliflora*, *Euphorbia caducifolia* and *Acacia senegal*, found associated with guggul plants in Pali district.



Figure 13. Chang- This site covers guggul population in 150 hectare and guggul population density is 11 plants per hectare.

Figure 14. Borwad – At this site guggul population is in 100 hectare area and guggul population density is 4 plants per hectare.



Figure 15. Kumbhsagar – This site has guggul population in 100 hectare area and guggul population density is 2 plants per hectare.

Figure 16. Jawaibandh – This site has guggul population in 100 hectare area and guggul population density is 49 plants per hectare.



Figure 17. Nimbo ka nath- This site exhibits guggul population in 100 hectare area and guggul population density is 19 plants per hectare.



Figure 18. Kalabhakar- This site has guggul population in 100 hectare area and guggul population density is 37 plants per hectare.

4. Barmer – In this district highest guggul population density was observed. It was 58 plants per hectare as calculated from posted data of all 4 sites. Sitewise details are given in Table 5.

S.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Pl
No.	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Barmer (Kiradu)	150	133	25°44.734′	071°05.527′	3
2	Barmer (Besala)	150	17	25°53.748′	071°13.925′	3
3	Barmer(Junapath	200	43	25°39.593′	071°13.554′	3
	rasar)					
1	Balotara (Nakora)	60	24	25°47 079'	072°09 321'	

Table 5. Status of Barmer district

In this district mainly *Prosopis juliflora, Euphorbia caducifolia* and *Acacia senegal*, were found minggled with guggul.





Figure 19. Kiradu- Here small size guggul plants were observed.Guggul population in 150 hectare area and guggul population density is 133 plants per hectare.

Figure 20. Besala- This site covers guggul population in 150 hectare area and guggul population density is around 17 plants per hectare.





Figure 21. Junapathrasar- This site covers guggul population in 200 hectare area and guggul population density is 43 plants per hectare.

Figure 22. Nakoda- This site has guggul population in 60 hectare area and guggul population density is around 24 plants per hectare.

5. Jaisalmer- Information received from SFD, Rajasthan did not give any account of guggul population in Jaisalmer but during survey guggul plants were observed at four locations. Average population density of all 4 sites was nearly 17 plants per hectare. The average population density of all these 4 sites (Aakal, Tamderay, Pol ji ki, Dhanua) is given in Table 6.

Plot

31 30 35

16

S.No.	Range/Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Jaisalmer (Pol ji ki)	50	17	26°49.903′	070°55.755′	18
2	Jaisalmer (Tamaderay)	120	25	26°44.041'	070°54.262′	26
3	Dabla (Aakal)	104	32	26°49.638′	071°02.538′	30
4	Dabla(Dhanua)	150	14	26°50.547′	070°58.868′	25

Table 6. Status of Jaisalmer district

Other common species found in guggul occuring areas of Jaisalmer were *Prosopis juliflora, Euphorbia caducifolia* and *Acacia senegal*.



Figure 23. Pol ji ki- This site covers guggul population in 50 hectare area and guggul population density is 17 plants per hectare.



Figure 24. Tamderay- This site covers guggul population in 120 hectare area and guggul population density is around 25 plants per hectare.



Figure 25. Aakal- This site covers guggul population in 104 hectare area and guggul population density is 32 plants per hectare.



Figure 26. Dhanua- This site has guggul population in 60 hectare area and guggul population density is 24 plants per hectare.

6. Jalore – Data were collected from five locations where the guggul plants were available. These five sites of Jalore are Bhadrajun, Chekla, Sundhamata, Silasan and Dodiyani. The average guggul population density of all three sites was found around 50 plants per hectare. The site wise population density is given in Table 7.

Table 7. Status of Jalore district

S.No.	Range/ Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Bhadrajun	100	33	25°35.306'	072°52.050'	23
2	Chekla	50	118	24°49.751'	072°25.388'	15
3	Sundamata	100	14	24°50.108'	072°21.697'	27
4	Silasan	50	32	24°50.216'	072°13.637'	24
5	Dodiyani	150	73	25°16.980'	072°53.977'	32

The other major associated plant species found were *Euphorbia caducifolia, Prosopis juliflora* and *Acacia senegal*.



Figure 27. Bhadrajun- This site exhibits guggul population in 100 hectare area. Guggul population density is 33 plants per hectare.



Figure 28. Chekla- This site has guggul population in 50 hectare area. Guggul population density is 118 plants per hectare.



Figure 29. Sundhamata- This site exhibits guggul population in 100 hectare area. Guggul population density is 14 plants per hectare.



Figure 30. Silasan- This site has guggul population in 50 hectare area. Guggul population density is 32 plants per hectare.

7. Nagaur – In this district total 4 sites were visited. The average guggul population density of all these sites was around 12 plants per hectare. The sitewise population density of these 4 sites is given in Table 8.

S.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
No.	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Palara	50	16	27°05.819'	074°49.403'	17
2	Sargot	50	15	27°04.396'	074°52.536'	21
3	Shyojiwala	30	10	26°52.628'	074°48.708'	14
4	Gingoli	50	12	26°54.091'	074°49.147'	18

Table 8. Status of Nagaur district

The other major associated plant species with guggul were *Prosopis cineraria, Prosopis juliflora, Ziziphus nummularia, Euphorbia caducifolia* and *Acacia senegal* in Nagaur district.



Figure 31. Palara - This site covers guggul population in 50 hectare area and population density of 16 plants per hectare.



Figure 32. Sargot - This site has guggul population in 50 hectare area. Guggul population density is 15 plants per hectare.



Figure 33. Shyojiwala- This location has 30 hectare area. Guggul population density is 10 plants per hectare.



Figure 34. Gingoli - This site has guggul population in 50 hectare area. Guggul population density is 12 plants per hectare.

8. Jhunjhunu- The average guggul population density was found around 69 plants per hectare of all the 2 sites visited in Udaipurvati and Khetri Range. The site wise population density of this district is given in Table 9.

Table 9. Status of Jhunjhunu district

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Kot	50	100	27°39.670'	075°25.812'	22
2	Dodafatehpura	50	29	28°00.193'	075°51.683'	17

Major plant species namely, *Prosopis juliflora, Euphorbia caducifolia* and *Acacia senegal*, *Argemone mexicana* found associated with guggul plants in Jhunjhunu district.





Figure 35. Kot– This site covers guggul population in 50 hectare and guggul population density is 100 plants per hectare.

Figure 36. Dodafatehpura – At this site guggul population is in 50 hectare area and guggul population density is 29 plants per hectare.

9. Sawai Madhopur – In this district highest guggul population density was observed. Here population density observed is 74 plants per hectare in surveyed area of 100 hectare. There was tremendous difference in guggul density of Tajpur (128 plants per hectare) and Chuli (8 plants per hectare) forest Block/Range of Sawai Madhopur District as shown in Table 10.

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Tajpur	50	128	26°25.985′	076°45.006'	20
2	Chuli	50	08	26°25.714'	076°43.118'	16

In this district mainly *Prosopis juliflora, Calotropis* and *Acacia senegal,* were found mingled with guggul.





Figure 37. Tajpur-Here guggal plants were in fully flowering stage and well in growth...Guggul population in 50 hectare area and guggul population density is 128 plants per hectare.

Figure 38. Chuli- This site covers guggul population in 50 hectare area and guggul population density is around 08 plants per hectare.

10. Karoli- In Range Mandrayal two sites were surveyed near revenge of Chambal river. Average population density of 2 sites (Pancholi, Barred) was nearly 47 plants per hectare. The average population density of all these 2 sites is given in Table 11.

Tab	le 11	. Status	of I	Karoli	i district	
lap	ie 11	Status	OTI	karoli	aistrict	

S.No.	Range/ Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Pancholi	100	68	26°19.413'	077°18.097'	25
2	Barred	100	27	26°17.238'	077°15.486'	26

Other common species found in guggul occuring areas of Mandrayal were Prosopis juliflora,





Figure 39. Pancholii- This site covers guggul population in 100 hectare area and guggul population density is 68 plants per hectare.

Figure 40. Barred- This site covers guggul population in 100 hectare area and guggul population density is around 27 plants per hectare.

11. Sikar - In this district Neem ka thana range surveyed where 50 ha Baleshwar site has Guggal population density of 49 plants per hectare. Other areas were lacking guggul natural population.

Table 12. Status of Sikar district

S.No.	Range/ Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Baleshwar	50	49	27°43.913'	075°52.878'	24

12. Sirohi- In this district 7 forest block sites were surveyed covering area of 450 hectare. Average population density was 11 plants per hectare and highest density was 22 plants per ha in Nadia Forest Block/Range. Density was lowest (7 plants pet hectare) in Matrmata and Moshal Forest Block/Range

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Lotana	150	10	24°46'43.3''	72°55'49.3''	31
2	Nadia	100	22	24°46'55.5''	72°56'31.4''	18
3	Darbari Khera	50	10	24°46'24.1''	72°50'04.7''	16
4	Kair	50	15	24°44'53.3''	72°50'53.0''	15
5	Matrmata	100	07	24°54'06.4''	72°57'17.2''	21
6	Moshal	50	07	25°06'16.2''	72°52'50.4''	17

Table 13. Status of Sirohi district

13. Alwar – Alwar district is rich in guggal plant density. The area near the fort is protected for wild life hence good growth of plants was observed. Forest area surveyed in Alwar District was 635 hectare and average density of all these areas was having 8.9 per hectare plants. After receiving the permission from SFD Rajasthan authorities two tours were conducted in Sariska (Alwar) and Birds Sanctury (Bharatpur) areas to complete remianing task of survey. Guggul was present in Sariska, Tal Vraksh and Tehala forest range only. In Alwer district major dominating trees were of Anogeissus species, Acacia senegal and shrub was Adhatoda vasica (Adusa).



Figure 41. Guggul plants growing in Talvrakhs Range, Rampura III, Sariska Area in Alwar District Close up view (left) Distance View (Right)

S.No.	Range/ Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1.	Alwar	300	10.7	27°34.906'	76°35.118'	38
2.	Bahroad	35	9.6	27°40.548'	76°27.634'	24
3.	Kishangarh	40	2.2	27°41.835'	76°38.210'	20
4.	Thanagaji	60	10.7	27°26.417'	76°14.772'	40
5.	Sariska	35	8.41	27°21'534'	76°19'361'	33
6.	Talwarks	110	6.1	27°27.010'	76°22.489'	98
7.	Tehala	35	6.3	27°11.597'	76°26.640'	35

Table 14. Status of Alwar district

14. Baran – Almost 240 ha area was covered in Baran district belonging to five forest ranges.Guggul density was highest 11.6 P/ha in Shabad and 4.4 P/ha in Chhabda forests range.Guggul was lacking in other three forests ranges viz. Anta, Kelwada and Kishanganj.

Table 15.	Status	of Baran	district
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S. No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1.	Anta	30	0	25°08.915'	76°15.148'	11
2.	Chhabda	50	4.4	24°41.990'	76°59.125'	25
3.	Kelwada	50	0	25°08.863'	76°52.806'	11
4.	Kishanganj	60	0	25°04.757'	76°45.471'	11
5.	Shahbad	50	11.6	25°14.640'	77°08.955'	18

15. Chittorgarh – Total forest area surveyed in Chittorgarh district was 220 hectare. Average plant density of all four forest ranges is about 6.6 plants per hectare plants. This district is not very rich in guggal plant density. Maximum population (14.1 plants per ha) was observed in Javda range followed by Vijaypur and Borav. Guggul was extremely scanty in Chittorgarh range. *Commiphora agallocha* was also observed in some of the ranges. Major dominant species were *Anogeissus pendula* and *Butea monosperma*. Total forest area surveyed in Chittorgarh district was 220 hectare having 6.6 plants per hectare.

Table 16. Status of Chittorgarh district

S.No.	Range/ Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Chittorgarh	55	0	24°57.478'	74°47.368'	29
2	Borav	50	5.9	25°00.825'	75°23.452'	17
3	Javda	30	14.1	24°49.539'	75°23.996'	15
4	Vijaypur	85	8.7	24°54.003'	74°47.780'	46

16. Dausa - Dausa forest ranges are having hilly terrain. The survey was done in Lalsot, Sikray and Bandikui ranges of Dausa district covering 200 ha area. Sikray range was having the highest density 13 plants per hectare amongst three forest ranges (table 16).

Table17.	Status	of Dausa	district
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S.No.	Range/ Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Bandikui	50	8	27 ⁰ 03.731'	076 ⁰ 26.767'	16
2	Lalsot	100	13	26 ⁰ 40.423'	076 ⁰ 25.494'	20
3	Sikray	50	5	26 ⁰ 59.373'	076 ⁰ 47.604'	17

17. Dungarpur – Total forest area surveyed in Dungarpur district was 240 hectare having 5.5 plants per hectare. Three forest range/forest block were surveyed maximum population (44 plants per ha) was in Aspur range followed by Sagwara and Simalwara. Guggul was extremely paucity in Dungarpur. Major dominant species were *Anogeissus pendula* and *Boswellia serrata*.

Table 18. Status of Dungarpur district

S.No.	Range/ Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Aspur	100	44	23 ⁰ 56.544'	074 ⁰ 00.178'	59
2	Sagwara	100	13	23 ⁰ 40.323'	073 ⁰ 58.475'	36
3	Simalwara	40	6	23 ⁰ 38.208'	074 ⁰ 49.645'	20

18. Jaipur – The district Jaipur having the wide range of hilly and plain terrain was surveyed in seven ranges namely Dudu adjoining to Ajmer, Kotputli, Bhilwadi, Sahpura, Viratnagar, raysar and Jamwaramgarh Sanctuary. The best guggul plants as per growth were found in Jamwaramgarh and density per hectare was second to Raysar range.

S.N o.	Range/ Forest Block	Area (hectare)	No. of plants (per hectare)	Latitude (N)	Longitude (E)	Sample Plot (30x30 m ²⁾ No.
1	Dudu	50	4	26 ⁰ 49.021'	073 ⁰ 20.687'	16
2	Kotputli	100	16	27 ⁰ 32.475'	075 ⁰ 58.376'	25
3	Bhilwari	50	19	27 ⁰ 29.711'	076 ⁰ 01.120'	21
4	Sahpura	100	10	27 ⁰ 17.615'	075 ⁰ 55.497'	27
5	Viratnagar	50	12	27 ⁰ 24.421'	076 ⁰ 10.908'	18
6	Raysar	50	37	27 ⁰ 08.572'	076 ⁰ 03.194'	18
7	Jamwaramgarh	100	27	27 ⁰ 05.510'	076 ⁰ 11.113'	25

Table 19. Status of Jaipur district

19. Jhalawar – In Jhalawar district 6 forest range were covered and almost 350 ha area was surveyed. Guggul was recorded in two forest ranges viz. Dug and Jhalawar with 5 and 10 p/ha respectively. *Commiphora agallocha* was also observed in these areas (Dug and Jhalawar). Other four (Aklera, Asnwar, Pidawa and Mishroli) ranges are either lacking guggul plants or they extremely rare.

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ⁻ ′ No.
1	Dug	50	5	24 ⁰ 01.055'	75 ⁰ 50.199'	18
2	Aklera	50	0	24 ⁰ 25.301'	76 ⁰ 35.141'	11
3	Asnwar	50	0	24 ⁰ 28.165'	76 ⁰ 20.700'	11
4	Jhalawar	100	10	24 ⁰ 34.376'	76º08.545'	35
5	Pidawa	50	0	24 ⁰ 09.621'	76 ⁰ 03.799'	15
6	Mishroli	50	0	24 ⁰ 12.046'	75 ⁰ 49.982'	11

Table 20. Status of Jhalawar district

20. Kota – In Kota district three ranges viz. Sultanpur, Dara and Sitamata were covered for guggul survey work. Guggul occurrence were observed in Sultanpur range only with a population density is about 13 plants per ha. In this area *Commiphora agallocha* was also observed.

Table 21. Status of Kota district

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Sultanpur	150	13	25°24.253'	76°09.400'	25
2	Dara	100	0	24°49.557'	76°00.851'	18
3	Sitamata	150	0	24º05.013' 74º35.073'		29

21. Rajsamand – Rajasamand district is having very high density of guggul plants in both the ranges viz. Rajasamand and Bhim. Bhim forest range is having average population density 194 plants per hectare and Rajasamand is having 75 plants per hectare in 380 and 400 ha surveyed area.

Table 22. Status of Rajsamand district

S.No.	Range/ Forest Area		No. of plants	Latitude (N)	Longitude (E)	Sample Plot	
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.	
1	Rajsamand	400	75	25º22.143	73 ⁰ 54.726	27	
2	Bhim	380	194	25 ⁰ 56.666	74 ⁰ 18.734	58	

22. Bharatpur – Two Forest Ranges viz. Bayana and Deeg were surveyed. Guggul was present in Bayana Forests Range only and average density was 66 plants per ha as calculated with 33 sample plots. Other species in dominance found associated with guggul plants in this forest range are namely, *Anogeissus pendula, Acacia senegal and Butea monosperma*.

Table 23. Status of Bharatpur district

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Bayana	90	66	26°59'05.2''	77°06'03.4''	33
2	Deeg	80	0	27°26'32.5''	77°17'15.2''	32
3	Bird Sanctuary	29	0	27°11.430''	77°30.890''	60

23. Dholpur – Five Forests Range were surveyed in Dholpur District. Average density of Bhilawara district as a whole was 7 plants per ha calculated from 106 sample plots. Other

species in these areas are *Prosopis juliflora, Zizyphus nummularia* and *Capparis decidua*. But in Sirmathura range *Anogeissus pendula and Butea monosperma* were other common species

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Bari	100	nil	26°44'17.9'	77°27'51.5'	18
2	Dholpur	50	12.1	26°40'39.9'	26°40'39.9' 77°55'34.7'	
3	Rajakhera	50	6.6	26°48'28.4'	78°06'15.7'	20
4	Sirmathura	100	8.0	26°24'14.1' 77°22'43.5'		22
5	Vanvihar	100	7.5	26°33'53.1'	77°45'02.7'	28

 Table 24. Status of Dholpur district

24. Bhilwara – Three Forest Range were surveyed in Bhilwara District. Average density of Bhilwara district as a whole was 11.8 plants per ha calculated from 86 sample plots. Other species in these areas are *Acacia nilotica* and *Prosopis juliflora*.

 Table 25. Status of Bhilwara district

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Aasind	130	11.2	25°48.453'	74°13.708'	47
2	Bhilwara	230	16.9	25°41.164'	74°07.319'	26
3	Gulabpura	60	3.4	25°28.250'	74°41.265'	13

25. Bundi – Four forest ranges were surveyed guggul population was recorded in Ramgarh and Indergarh ranges about 13 plants per ha calculated on the basis of 72 samples plots. Forest Range wise brief status of population density is given in table 26. Other species in these areas are *Anogeissus pendula* and *Prosopis juliflora*

Table 26. Status of Bundi district

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Hindoli	50	0	25°37.533'	75°28.355'	20
2	Bundi	50	0	25°26.766'	75°37.200'	18
3	Ramgarh	100	12	25°30.618'	75°51.871'	32
4	Indergarh	100	14	25°29.615'	75°52.630'	40

26. Tonk – Three forests range were surveyed in Tonk district but guggul was present only in Devali forest range in a 50 ha area with with a population density of 13 plants per ha. Other species in these areas are *Anogeissus pendula, Acacia senegal* and *Acacia leucophloea*.

	Table 27	. Status	of Tonk	district
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S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Uniyara	30	0	26°01.866'	75°55.781'	10
2	Malpura	30	0	26°13.996'	75°24.753'	15
3	Devali	50	13	25°56.476'	75°27.791'	20

27. Udaipur – Two Forest Ranges were surveyed in Udaipur District and average population density of both areas is about 17.4 plants per ha. Other species in these areas are *Anogeissus pendula, Butea monosperma* and *Acacia senegal.*

S.No.	Range/ Forest	Area	No. of plants	Latitude (N)	Longitude (E)	Sample Plot
	Block	(hectare)	(per hectare)			(30x30 m ²⁾ No.
1	Sarada	230	15.5	24°20.937'	73°47.815'	64
2	Udaipur	50	24.6	24°35.804'	73°39.034'	17

Table 28. Status of Udaipur district

Team also visited Banswara, Bikaner, Churu, Hanumangarh, Pratapgarh, Sri Ganganagar district and met DFO Churu. They enquired from RFOs about guggul occurrence in their respective areas. SFD officials informed AFRI team that Guggul population was not observed in Churu districts. AFRI team visited Taranagar range and there no guggal population was recorded.

Statistical Analysis:

All 33 districts are covered viz. Ajmer, Alwar, Banswara, Baran, Barmer, Bharatpur, Bhilwara, Bikaner, Bundi, Chittorgarh, Churu, Dausa, Dholpur, Dungarpur, Hanumangarh, Jaipur, Jaisalmer, Jalore, Jhalawar, Jhunjhunu, Jodhpur, Karauli, Kota, Nagaur, Pali, Pratapgarh, Rajsamand, Sawai Madhopur, Sikar, Sirohi, Sri Ganganagar, Tonk and Udaipur. Guggul density is found high in Sawai Madhopur (≈74 ha⁻¹) and Jhunjhunu (≈69 ha⁻¹) districts. Survey also revealed that Bikaner, Banswara, Churu, Shri Ganganagar, Hanumangrah and Pratapgrah districts are lacking natural guggul population. Whole data collected so far from 33 districts is classified on the basis of population density, which is summarized in following table 29.

Po Cla	pulation Density ss	No. of District	Name of Districts			
1.	A (>40 plants/ha)	7	Barmer, Bharatpur, Jalore, Jhunjhunu, Karoli, Sawai Madhopur and Sikar,			
2.	B (11-40 plants/ha)	11	Ajmer, Bhilwara, Bundi, Jaisalmer, Jodhpur, Nagaur, Pali, Rajsamand, Sirohi, Tonk and Udaipur			
3.	C (1-10 plants/ha)	9	Alwar, Baran, Chittorgarh, Dausa, Dholpur, Dungarpur, Jaipur, Jhalawar, Kota,			
4.	D (<1 plants/ha)	6	Banswara, Bikaner, Churu, Ganganagar, Hanumangarh, Pratapgarh			

Summary Table 29:

Dist	ricts	Area	Average	Sample	Sample	Vari-	Popula	Popula-
		(ha)	no. of plants /ha	mean	S.D.	ance	-tion S.D	tion Variance
1.	Ajmer	171	36.1	4.3	7.0	48.4	6.8	46.9
2.	Alwar	435	9.9	0.9	0.96	0.92	0.96	0.91
3.	Banswara*	nil	nil	nil	nil	nil	nil	nil
4.	Baran	100	4.5	0.4	0.95	0.90	0.94	0.89
5.	Bundi	300	2.6	0.2	0.5	0.25	0.5	0.25
6.	Chittorgarh	165	6.6	0.6	1.45	2.09	1.44	2.07
7.	Jodhpur	1260	35.1	3.2	3.4	11.7	3.4	11.7
8.	Pali	700	20.6	1.9	2.2	4.9	2.2	4.9
9.	Barmer	560	58.3	5.2	5.4	29.3	5.4	29.0
10.	Jaisalmer	424	23.0	2.1	1.8	3.2	1.8	3.2
11.	Jalore	450	50.0	4.5	5.3	27.8	5.2	27.5
12.	Nagaur	180	12.0	1.1	1.1	1.2	1.1	1.2
13.	Jhunjhunu	100	69.0	6.0	6.6	43.4	6.5	42.3
14.	Jaipur	500	9.5	0.9	1.41	2.00	1.41	1.99
15.	Jhalawar	150	1.6	0.1	0.59	0.35	0.59	0.35
16.	Sawai Madhopur	100	74.0	9.4	10.5	110	10.3	107
17.	Karoli	200	47.0	4.2	4.7	22.4	4.7	22
18.	Kota	150	3.4	0.3	0.77	0.60	0.76	0.58
19.	Sikar	50	49.0	4.4	3.7	13.7	3.6	13.2
20.	Sirohi	450	11	1.0	1.2	1.6	1.2	1.6
21.	Churu*	nil	nil	nil	nil	nil	nil	Nil
22.	Dausa	200	5.5	0.5	0.78	0.60	0.77	0.59
23.	Dholpur	106	6.95	0.92	0.81	0.66	0.81	0.66
24.	Dungarpur	240	5.1	0.5	0.72	0.52	0.72	0.51
25.	Bharatpur	33	6.3	0.57	0.78	0.61	0.78	0.61
26.	Pratapgrah*	nil	nil	nil	nil	nil	nil	Nil
27.	Bikaner*	nil	nil	nil	nil	nil	nil	Nil
28.	Hanumangarh*	nil	nil	nil	nil	nil	nil	Nil
29.	Sri Ganganagar*	nil	nil	nil	nil	nil	nil	Nil
30.	Bhilwara	420	11.9	1.07	1.2	1.3	1.2	1.3
31.	Rajsamand	780	36.3	3.27	3.2	10.3	3.2	10.1
32.	Tonk	110	2.8	0.2	0.6	0.36	0.6	0.36
33.	Udaipur	380	17.5	1.58	1.3	1.6	1.3	1.6

 Table 30. District wise statistical analysis

*S. No. 3, 21, 26-29 Districts (shaded) are lacking natural Guggul population.

II) Germplasm collection:

Identity of CPP's (location, Site and District etc) and number of stem cuttings collected during survey work is given in table 31.

S. No.	CPT No. /Clone	No. of cuttings	Latitude(N)	Longitude(E)	Altitude (feet)	CPP's site	District
1	JDP1	10	26°17.522'	072°53.765'	988	Arna	Jodhpur
2	JDP2	11	26°18.628'	072°54.596'	995	Barli	Jodhpur
3	JDP3	11	26°17.922'	072°58.129'	960	Badabhakar	Jodhpur
4	JDP4	12	26°41.237'	073°03.580'	1085	Mewasa	Jodhpur
5	JDP5	12	26°41.251'	073°03.598'	1125	Mewasa	Jodhpur
6	JDP6	12	26°24.369'	073°02.246'	865	Daizar	Jodhpur
7	JDP7	18	26°24.401'	073°02.301'	860	Daizar	Jodhpur
8	JDP8	11	26°22.990'	073°03.409'	851	Beriganga	Jodhpur
9	JDP9	12	26°23.020'	073°03.426'	846	Beriganga	Jodhpur
10	PAL1	12	24°54.802'	073°09.251'	1294	Kumbhsagar	Pali
11	PAL2	05	24°54.661'	073°09.288'	1286	Kumbhsagar	Pali
12	PAL3	08	24°54.603'	073°09.272'	1266	Kumbhsagar	Pali
13	PAL4	12	25°16.310'	073°11.684'	1140	Nimbo ka nath	Pali
14	PAL5	08	25°16.289'	073°11.678'	1093	Nimbo ka nath	Pali
15	PAL6	12	25°05.960'	073°10.175'	1054	Jawai bandh	Pali
16	PAL7	14	26°07.003'	074°14.462'	1699	Chang	Pali
17	PAL8	12	26°06.994'	074°14.442'	1692	Chang	Pali
18	PAL9	12	26°17.026'	074°14.380'	1600	Chang	Pali
19	BMR1	12	25°47.138'	072°09.342'	1106	Nakoda	Barmer
20	BMR2	12	25°47.079'	072°09.321'	1240	Nakoda	Barmer
21	BMR3	12	25°47.082'	072°09.329'	1220	Nakoda	Barmer
22	BMR4	12	25°44.843'	071°05.399'	1037	Kiradu	Barmer
23	BMR5	12	25°44.774'	071°05.331'	1241	Kiradu	Barmer
24	BMR6	12	25°39.639'	071°13.424'	1145	Junapathrasar	Barmer
25	BMR7	12	25°53.758'	071°13.920'	878	Besala	Barmer
26	BMR8	12	25°53.863'	071°13.961'	911	Besala	Barmer
27	BMR9	12	25°53.865'	071°13.882'	852	Besala	Barmer
28	BMR10	12	25°53.845'	071°13.853'	860	Besala	Barmer
29	JSL1	12	26°49.603'	071°02.537'	796	Aakal	Jaisalmer
30	JSL2	12	26°49.503'	071°02.424'	826	Aakal	Jaisalmer
31	JSL3	12	26°49.698'	071°02.764'	771	Aakal	Jaisalmer
32	JSL4	12	26°49.661'	071°02.524'	789	Aakal	Jaisalmer
33	JSL5	12	26°50.464'	070°59.048'	805	Dhanua	Jaisalmer

Table 31. Status of CPP's collection

34	JSL6	12	26°44.333'	070°54.252'	958	Tamaderay	Jaisalmer
35	JSL7	12	26°43.996'	070°54.372'	901	Tamaderay	Jaisalmer
36	JSL8	12	26°44.285'	070°54.224'	943	Tamaderay	Jaisalmer
37	JSL9	12	26°44.227'	070°54.169'	944	Tamaderay	Jaisalmer
38	JLR1	12	25°35.260'	072°52.046'	773	Bhadrajun	Jalore
39	JLR2	12	24°49.798'	072°25.293'	873	Chekla	Jalore
40	JLR3	12	24°49.768'	072°25.320'	949	Chekla	Jalore
41	JLR4	12	24°50.408'	072°13.690'	725	Silasan	Jalore
42	JLR5	12	24°50.184'	072°13.675'	860	Silasan	Jalore
43	JLR6	12	25°17.043'	072°54.028'	823	Dodiyani	Jalore
44	JLR7	12	25°17.005'	072°54.031'	964	Dodiyani	Jalore
45	NGR1	12	26°52.599'	074°48.715'	1437	Shyojiwala	Nagaur
46	NGR2	12	26°54.177'	074°49.093'	1435	Gingoli	Nagaur
47	SIR1	12	24°46′385″	072°56'129"	412m	Nadia	Sirohi
48	SIR2	12	24°46′485″	072°56'381"	399m	Nadia	Sirohi
49	SIR3	12	24°46'433"	072°55'493"	438m	Lotana	Sirohi
50	SIR4	12	24°46′448″	072°56'091"	391m	Lotana	Sirohi
51	SIR5	12	24°46'265"	072°49'562"	433m	Darbarikhera	Sirohi
52	SIR6	12	24°46'243"	072°56'028"	417m	Darbarikhera	Sirohi
53	SIR7	12	24°52′285″	072°52′529″	346m	Matrmata	Sirohi
54	SIR8	12	24°54'054"	072°57'184"	455m	Matrmata	Sirohi
55	SIK1	12	27°43.910'	075°52.870'	1554	Baleshwar	Sikar
56	SIK2	12	27°43.880'	075°52.922'	1558	Baleshwar	Sikar
57	SIK3	12	27°43.887'	075°52.943'	1551	Baleshwar	Sikar
58	SIK4	12	27°29.652'	075°11.251'	1504	Harsh Parvat	Sikar
59	JJN1	12	27°39.708'	075°25.856'	1758	Kot	Jhunjhunu
60	JJN2	12	27°39.690'	075°25.839'	1756	Kot	Jhunjhunu
61	JJN3	12	28°00.245'	075°51.698'	1329	Dodafatehpura	Jhunjhunu
62	JJN4	12	28°00.219'	075°51.689'	1320	Dodafatehpura	Jhunjhunu
63	SMP1	12	26°26.051'	076°45.041'	1118	Tajpur	Sawai
64	SMP2	12	26°26.997'	076°45.020'	1153	Tajpur	Madhopur
65	KRL1	12	26°19.413'	077°18.097'	696	Pancholi	Karoli
66	KRL2	12	26°19.366'	077°18.165'	683	Pancholi	Karoli
67	KRL3	12	26°17.417'	077°15.524'	583	Barred	Karoli
68	BLW1	12	25°41.166'	74°07.388'	1893	Shikarwari	Bhilwara
69	BLW2	12	25°53.674'	74°17.894'	1788	Bhiratmata	Bhilwara
70	BLW3	12	25°28.240'	74°41.223'	1468	Banera	Bhilwara
71	RJSMD1	12	25°22.226'	73°54.742'	2657	Aamet (shimata)	Rajsamand
72	RJSMD2	12	25°22.469'	73°49.318'	2664	Nardas ka guda	Rajsamand
73	RJSMD3	12	25°31.857'	74°01.603'	2081	Madaria	Rajsamand
74	RJSMD4	12	25°31.894'	74°01.566'	2091	Madaria	Rajsamand
75	RJSMD5	12	25°31.925'	74°01.545'	2053	Madaria	Rajsamand
L	1	1	1	1	1	1	

76	RJSMD6	12	25°31.549'	74°01.599'	2057	Madaria	Rajsamand
77	UDAP1	12	24°35.933'	73°49.937'	2458	Sajjangarh	Udaipur
78	UDAP2	12	24°35.933'	73°49.738'	1468	Palona	Udaipur
79	UDAP3	12	24°19.244'	73°49.846'	1515	Palona	Udaipur
80	UDAP4	12	24°18.146'	73°50.960'	1501	Palona	Udaipur
81	Dus1	12	26°40.56'	76°25.531'	1020	Ghata Lalsot	Dausa
82	Dus2	12	25°59.358'	76°47.995'	750	Chandra	Dausa
83	JP1	12	25°49.045'	75°20.687'	1312	Bichoon	Jaipur
84	JP2	12	27°32.586'	75°58.923'	1650	Buchara	Jaipur
85	JP3	12	27°19.656'	75°55.836'	1515	Kerli	Jaipur
86	JP4	12	27°24.421'	76°10.908'	1366	Viratnagar	Jaipur
87	JP5	12	27°08.888'	76°03.196'	1187	Bhilod	Jaipur
88	ALWR1	12	27°34.691'	76°35.411'	1803	Bala fort	Alwar
89	ALWR2	12	27°34.512'	76°35.495'	1237	Nidani	Alwar
90	ALWR3	12	27°31.378'	76°34.931'	988	Bakhera	Alwar
91	ALWR4	12	27°42.741'	76°33.603'	1171	Chandoli	Alwar
92	ALWR5	12	27°40.440'	76°27.426'	1613	Damal ka was	Alwar
93	ALWR6	12	27°26.366'	76°14.731'	1550	Bandrol	Alwar
94	ALWR7	12	27°26.585'	76°14.990'	1614	Maluthana	Alwar
95	CHTO1	12	24°49.595'	75°24.025'	1566	Agara	Chittorgarh
96	CHTO2	12	24°54.294'	74°47.619'	1785	Gorsiya	Chittorgarh
97	CHTO3	12	24°52.934'	74°47.730'	1573	Dhunwala	Chittorgarh
98	CHTO4	12	25°00.866'	75°23.589'	1380	Nahargarh	Chittorgarh
99	JHLW1	12	24°01.134'	75°50.269'	1518	Kolvi	Jhalawar
100	JHLW2	12	24°01.139'	75°50.257'	1533	Kolvi	Jhalawar
101	JHLW3	12	24°34.421'	76°08.561'	1273	Raipur	Jhalawar
102	KOT1	12	25°24.350'	76°09.463'	745	Piplda sand	Kota
103	KOT2	12	25°24.382'	76°09.474'	758	Piplda sand	Kota
104	BARAN1	12	25°14.666'	77°08.983'	1184	Shabad	Baran
105	BARAN2	12	24°41.990'	76°59.125'	1240	Jefla	Baran
106	DGPR1	12	23°55.763'	74°00.223'	1074	Khadasamor	Dungarpur
107	DGPR2	12	23°41.409'	73°59.754'	1213	Nawaghora	Dungarpur
108	DGPR3	12	23°38.298'	73°49.813'	1115	Bedsa Umraphla	Dungarpur
109	TOK1	12	25°56.460'	75°27.895'	1151	Toda Raisingh	Tonk
110	BND1	12	25°29.615'	75°52.630'	797	Lolwa	Bundi
111	BND2	12	25°30.120'	75°51.356'	804	Kesarpura	Bundi
112	DLP1	12	26°33.741'	77°44.860'	528	Basedan	Dholpur
113	DLP2	12	26°24.233'	77°22.746'	561	Jeeri	Dholpur
114	DLP3	12	26°48.403'	78°06.288'	476	Jaitpur	Dholpur
115	DLP4	12	26°40.225'	77°55.251'	453	Bharakhera	Dholpur
116	BRTP1	12	26°59.146'	77°06.126'	843	Hatasee B	Bharatpur
117	BRTP2	12	27°00.491'	77°06.240'	781	Hatasee A	Bharatpur

III) Flowering and fruiting Phenology:

Guggal population at Kaylana (Jodhpur) was selected for annual studies of flowering and fruiting behaviour in Rajasthan where *Commiphora wightii* is growing in natural habitat. Observations on flowering and fruiting were recorded in each month from 66 guggal plants growing in this area. Annual pattern of flowering and fruiting is given in figure 42.



Fig 42. Flowering behavior of the year 2009-10

Data were also recorded on 66 plants to study degree of flowering and fruiting (flowering and fruiting intensity). Following scoring method was adopted to study the flowering intensity as given in following table and average flowering and fruiting intensity (total score/66 plants) is presented in figure 43.

Flowering/fruiting Intensity	Relative Score
No flowering/fruiting	0
10% branches flowering/fruiting	1
20% branches flowering/fruiting	2
30% branches flowering/fruiting	3
40% branches flowering/fruiting	4
50% branches flowering/fruiting	5
60% branches flowering/fruiting	6
70% branches flowering/fruiting	7
80% branches flowering/fruiting	8
90% branches flowering/fruiting	9
100% branches flowering/fruiting	10

Average score of 66 plants in each month is shown in following graph. Maximum flowering intensity was recorded in April and fruiting May.



Fig. 43 Flowering and fruiting intensity in Guggul plants at Jodhpur district

IV) Seed studies:

In Jodhpur, guggul plants produce fruits twice a year i.e. from April to July (main fruiting season) and from October to December (delayed fruiting season). No fruiting was observed in Barmer and Jaisalmer districts surveyed in the month of November and December. Immature fruits were observed in Ajmer, Jodhpur and Pali districts during survey in the month of August, October and November, respectively. These immature fruits were collected (from Barli and Arna sites of Jodhpur district) for in vitro germination. Mature fruits were not available at any of sites surveyed during this period (from August to December 2010).

Fruits: Fruit of *commiphora wightii* is a drupe, 6-8 mm. in diameter, ovoid, acute, red when ripe, epicarp longitudinally separated into two fleshy halves, leaving a 4 cleft slender orange red pulp (Fig. 44A). Endocarp of the fruit is very hard. Fruits with endocarp are ovoid, bilobed, sometimes trilobed or rarely tetralobed. They are yellowish white-black and black in color. Fruits having white endocarp do not contain seeds while that with black endocarp contains one or more seeds. Seeds are small, creamish white and smooth (Fig. 44B). Seeds are present in one or both the locules and one seed may contain one, sometimes two or rarely three embryos (Fig. 45A-D).



Fig 44: A. Mature fruits of Commiphora wightii, B. Mature fruits without epicarp

From Kaylana (Jodhpur) field mature fruits were collected in March. Two types of seeds, viz. black and white were observed in mature fruits (Figure 46). The seeds were then air dried and then kept in separate well labelled air tight plastic containers at room temperature. Both black and white seeds were sown. Only the black-coloured seeds were viable while white seeds were non-viable. Germination percentage of black seeds was found to be 40%. Seeds germinated within 5-16 days after sowing (Figure 47). One seed may produce more than one seedling due to its polyembryonic nature. One to four seedlings may emerge from a single seed.



Fig. 45:

C. Seed with single embryo

D. Seed with two embryos





Fig. 47: Germinated black seeds

The seeds were then air dried and subsequently divided randomly into 8 seed lots and then kept in separate well labeled air tight plastic containers at room temperature. 4 replicates of 50 black and 50 white seeds were sown. These were sown in sand medium in pots in polyhouse. Utmost care was taken to keep the germinating medium moist by adding a small quantity of water, whenever needed. Emergence of plumule above the sand was taken as the criterion for germination. The germination of seeds was recorded everyday upto 21 days from the day of sowing. Over all germination percentage of black seeds was was 47% from Kayalana source.

Mean germination % = $\left(\frac{24 + 24 + 25 + 21}{200}\right) \times 100 = 47 \%$

Days	Sul	o-san	nples	(4	Dai	Cumulat	Cumulativ	Mean	Daily total	Cumulative
after		× 50	black	2	ly	ive	e Total as	daily	as %of	total as % of
sowing		see	eds)		Tot	Total	% of total	germinat	germinabl	germinable
	Α	В	С	D	al		seeds	ion %	e seeds	seeds
1	-	-	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	-	-	-	-	-	-
5	-	-	-	-	-	-	-	-	-	-
6	1	-	1	-	2	2	1	0.17	2	2
7	2	-	1	-	3	5	2.5	0.36	3	5
8	3	4	3	2	12	17	8.5	1.06	13	18
9	2	3	3	4	12	29	14.5	1.61	13	31
10	2	3	4	3	12	41	20.5	2.05	13	44
11	3	3	2	2	10	51	25.5	2.32	11	54
12	3	4	3	3	13	64	32	2.67	14	68
13	4	3	5	3	15	79	39.5	3.04	16	84
14	2	1	2	3	8	87	43.5	3.12	8	92
15	1	2	1	0	4	91	45.5	3.03	4	97
16	1	0	0	1	2	93	46.5	2.91	2	99
17	0	1	0	0	1	94	47	2.76	1	100
Totals	24	24	25	21	94				100	

Table 32: Germination Test

Seed germination energy - it is determined by method given by Seward (1980). In this method germination energy is the percentage of germination when mean daily germination (cumulative germination divided by time elapsed since sowing date) reaches its peak. In the present example (Table 6) the peak of mean daily germination percent is 3.12%, the energy period is 14 days and the germination % is

$$\left(\frac{2+3+12+12+12+10+13+15+8}{200}\right) \times 100 = \left(\frac{87}{200}\right) \times 100 = 43.5\%$$

Percentage of total germinated seeds within the energy period was measured with following equation.

Percentage of total germinated seeds = $\left(\frac{87}{94}\right) \times 100 = 92\%$



Genotype Effect: Seeds were collected from different 26 genotypes from 6 locations of Rajasthan and Gujarat. It is a fact that black seeds have high germination percentage. Therefore, it was interesting to compare the percentage of black seeds from different genotypes. This study is important for conservation of such genotypes which has high black seed ratio. Black seeds percentage ranged from 38 to 100% (Fig. 48).



Fig. 48: Black seeds percentages in different genotypes belonging to different locations.

Detailed Guidelines prepared on our experience and previous literature for seed germination of Guggul plants in nursery beds for field staff in Hindi is attached with this report as Annexure A.

v) Macropropagation:

It is reported in literature that guggul stem cuttings can be rooted successfully (Soni 2010). Undoubtedly, this species is easy to propagate vegetatively but like other species in this species also rooting is influenced by source material (Location, age of plant, genotypes). Stem cuttings collected from different sources exhibited differential response in sprouting as well as rooting. Sprouting of stem cuttings starts within 20 days, but rooting is not synchronised with sprouting and it takes relatively longer time (about 30-40 days).

Annual Pattern of Rooting: Stem cuttings raised in mist-polyhouse in different months (except July-August months) of a year to study the annual pattern of sprouting and rooting and to find out the ideal period of raising stem cuttings with maximum success. Maximum rooting (about 48%) was recorded in January to February though sprouting was maximum (above 70%) in the months from March to June (Fig. 49). It indicates that sprouting is not a good indicator of rooting and bud break and initial growth of shoots is an independent process.



Fig. 49: Percentage of sprouting and rooting in different period of a year. Data of two months is combined in following graph.

Rooting behaviour of stem cutting collected from Different sources: Stem cutting collected from different 14 sources exhibit high variability in sprouting and rooting. Maximum rooting (60%) was recorded in Jalore and Bhilwara sources when stem cuttings were raised on 17 Januray 2011 and 27 April 2012, respectively (Fig 50). Whereas rooting was poor (below 20%) in stem cuttings collected from Udaipur (24 June), Jaisalmer (25 Dec), Nagaur (9 Feb), Barmer (24 Nov) and Jhunjhunu (18 Feb).



Fig 50: Sprouting and rooting percentage in stem cuttings collected from different sources

Genotype Response: Data analysis of cuttings exhibited tremendous difference in sprouting and rooting responses in different CPPs belonging to same locations. It is difficult to rule out the effect of age. Determination of age of individual genotype is difficult in natural population. However, genotypes exhibited above 90% rooting as well as sprouting was recorded in seven genotypes viz. PAL2, PAL3, PAL9, JLR1, JLR2, JLR7 & BLW2 (Fig. 51). Some of the genotypes of same location did not root well in spite of raised at same time and in similar conditions viz. PAL 1, PAL 4 & PAL 8 & JLR3, JLR4, JLR6 & BLW 3. The influence of age factor in present studies cannot be ruled out.





Fresh Cuttings vs Stored Stem Cuttings: When stem cuttings were collected from the field for our Institute, many times there was a delayed 3-4 days before raising them in Mist chamber for rooting. So the data was analysed and compared with freshly raised cuttings (0 day) vs cuttings stored at normal room temperature in air container for 1, 2, 3 & 4 days. Interestingly stem cuttings raised after 2-3 days responded better than freshly raised stem cuttings (Fig. 52) for sprouting as well as rooting. Experiment was repeated and results were almost same. All the rooted cuttings were tagged and maintaned in polyhouse for hardening. Subsequented all this germplasm is transplanted in field.

Data on temperature and relative humidity inside mist polyhouse were recorded with help of data loggers and annual pattern of temperature (Mean±SD) and RH % (Mean±SD) of different months is given in table 33.

Months	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec.
Temp	17±5	20±2	27±3	32±9	35±8	36±5	34±5	32±5	28±1	29±7	25±7	19±7
RH %	52±20	28±08	23±09	62±27	56±24	52±12	67±17	80±16	93±03	72±21	75±19	72±18

Table 33:



Fig. 52: Sprouting and rooting of fresh stem cuttings vs stored stem cuttings for few days when raised in Mist Polyhouse.



Fig. 53: Stem cuttings growing in mist polyhouse

Application of Auxins:

Two artificial auxins, known as IBA and NAA, are most commonly used. In Guggul combination of IBA and NAA (5 mg/l each) treatment for 5 sec. was found better to improve the rooting percentage (10 to 15% higher) as compare to control (without Auxin).

Detailed **Guidelines in Hindi** for Vegetative Propagation of Guggul plants in Mist Chamber is attached as Annexure B with this report for field staff.

VI. Genetic Characterization (DNA Marker studies):

One 109 genotypes collected from 33 districts were analyzed for DNA marker studies to evaluate the genetic diversity in the state and characterize individual genotypes. Germplasm collected for *ex situ* conservation from identified 117 CPPs. About 1428 vegetative cuttings with source details (GPS locations) were collected and raised in our vegetative propagation area for rooting. Differential response in sprouting and rooting was studied.

A. Progenies of 30 CPPs:

Thirty CPPs were identified from Rajasthan as well as from Gujarat with a view to study the breeding behaviours in these species by using Genetic markers (DNA and Isozyme). About 300 plants were raised through seeds collected from CPPs belonging to three sites of Gujarat and three from Rajsathan State. All the germplasm is subjected to genetic charecterization along with mother trees. These studies revealed that many genotypes are producing genetically different progenies indicate non apomictic genotypes. But some mother trees produce genetically identical offsprings along with few non identical offsprings. Details of same is given in next paragraphs.

1. Genetic Characterization of Germplasm and Progenies:

A. DNA Marker studies CPPs: The dendrogram shows genetic relationships among 109 individual plants of *Commiphora* (Figure 54). Out of these 98 genotypes belong to *Commiphora wightii* and the rest of 11 genotypes to *Commiphora agallocha*. The dendrogram comprises of two major clusters: one cluster consisting 9 genotypes of *C. agallocha* and the other cluster having 98 genotypes of *C. wightii* and 2 genotypes of *C. agallocha*.

All genotypes of a few populations like that of Bharatpur, Dholpur, Sikar, Udaipur, Dungarpur, Nagaur, Baran and Jhalawar show identical DNA (RAPD) pattern. Whereas a few genotypes of some populations of Pali, Sikar, Alwar, Karauli, Jhunjhunu, Jaisalmer, Jodhpur, Rajsamand also show identical RAPD patterns.

Dendrogram joins the individuals of the same population into compact groups and no individual of any given population clustered with individuals from another population.



Figure 54: Dendrogram showing genetic distances amongst 98 *C. wightii* and 11 *C. agallocha* genotypes.

Genetic Distance by Jaccard's similarity coefficient

B. DNA Marker studies of Progenies:

All six primers were found to distinguish all the accessions on the basis of polymorphism. Total numbers of 84 scorable RAPD bands ranging from 400 to 3000 bp were obtained out of which one band was monomorphic and 83 bands were polymorphic. The number of clear and interpretable bands for primers OPA-04, OPA-09, OPA-20, OPN-06, OPN-16 and OPN-20 were 19, 15, 9, 12, 14 and 15 respectively (Table 34). Here, the presence and absence of bands has been used to categorize the similarity and variation among the accession studied.

S.No.	Primers	Primer sequences	No. of frag- ments	Size of fragments (base pair)	No. of Poly- morhic fragments	Poly- morphism (%)
1.	OPA 04	5'-AATCGGGCTG-3'	19	400-3000	19	100%
2.	OPA 09	5'-GGGTAACGCC-3'	15	700-3000	15	100%
3.	OPA 20	5'-GTTGCGATCC-3'	9	1200-3000	9	100%
4.	OPN 06	5'-GAGAGGCACA-3'	12	500-2800	12	100%
5.	OPN 16	5'-AAGCGACCTG-3'	14	500-3000	14	93%
6.	OPN 20	5'-GGTGCTCCGT-3'	15	400-3000	15	100%

Table 34: List of the RAPD primers used for the study to calculate genetic variability among mother plants of different locations.

Cluster analysis was done using Jaccard's coefficient similarity matrix among the accessions. Dendrograms were made using similarity matrix. By comparing all the 30 mother plants of both Rajasthan and Gujarat sites it was observed that the population are of mixed type. They form 2 main clusters which are further divided into 4 different groups. The mother plants of Banas Kantha, Mahesana and Barmer form one cluster and mother plants of Kachchh, Rajsamand and Jodhpur forms the other. The band with mol wt. 1300 bp amplified with primer 5 was present in all mother plants and progenies of Banas kantha, Mahesana and Barmer region showing sort of genetic similarity between them. Similarly the band with mol. Wt. 1500 bp amplified with primer 3 was restricted only to mother plants and progenies of Kachchh, Jodhpur and Rajsamand accessions.

The band with mol wt. 800 bp amplified with primer 5 was found to be monomorphic, present in all mother plants of Gujarat and Rajasthan region. The bands with primer 2 (MW: 2800 and MW: 950), primer 5 (2500 bp), primer 6 (MW: 3000 bp) were restricted only to progenies and absent in all the mother plants. Two mother plants of Kachchh region (M14 and M15) were found to be genetically identical to each other (Figure 55). Similarly, 6 out of 8 progenies of mother plants M11 and M12 of Kachchh region were found to be genetically identical.

Figure 55: Dendrogram showing genetic distances among 30 mother plants (15 from Rajasthan and 15 from Gujarat) generated by DNA marker studies (RAPD).



The total primers observed concluded that all the 219 progenies from 30 mother plants of Rajasthan and Gujarat were genetically varied from their mother plants. The maximum similarity coefficient among mother and their progenies was observed with progenies of Barmer which were highly similar to their mother plants like plant no. 29 progeny no. P1 and P3 with similarity index 0.974.

C. ISOZYMES

The isozymes profiles were compared to assess the genetic variability among the mother plants and their progenies of Gujarat and Rajasthan region. The results of study are based on Peroxidase (PRX) and Acid phosphatase (ACP) analysis of *Commiphora wightii* genotypes. Cluster analysis was done using Jaccard's coefficient similarity matrix among the species by the biochemical compositions. Dendrograms were made using similarity matrix. Here, the presence and absence of bands has been used to categorize the similarity and variation among the accessions studied.

The isozymes profiles revealed that the population of Gujarat and Rajsthan were of mixed type. The cluster analysis made with Jaccard's similarity coefficient revealed that all the 30 mother plants are clustered into 4 main groups (Figure 56). Group A consist of Banas kantha, Mahesana, Kachchh, Rajsamand and Jodhpur, group B consist of Barmer and Banas Kantha, group C consist of Banas Kantha, Jodhpur and Mahesana and group D consist of Banas Kantha, Rajsamand, Mahesana and Barmer region. Five out of thirty mother plant's progeny revealed high percentage of apomixis. Four (M27, M28, M29 & M30) were from Barmer (Rajasthan) and fifth one (M7) was from Mahesana (Gujarat).

PEROXIDASE: A total of 12 bands were produced by profiling of peroxidase (Rf value ranges- 0.18-0.77). The data analysed revealed that the band with R_f value 0.6 is highly polymorphic. Band with R_f value 0.38 was present in all mother plants and progenies of Gujarat region whereas absent in Rajasthan. Similarly Band with R_f value 0.6 was present in all mother plants of Rajasthan region whereas absent in Gujarat accessions. The band with Rf value 0.77 was present and the band with R_f values 0.32, 0.36 and 0.38 were absent in Rajasthan accessions. The band with R_f value 0.36 was showing its uniqueness by restricting itself to Banas kantha region of Gujarat. Band with R_f value 0.18 is only restricted to the progenies and absent in all mother plants.

ACID PHOSPHATASE A total of 8 bands were produced by profiling of acid phophatase (R_f value ranges 0.1-0.6). The data analysis revealed that the band with R_f value 0.1 was present only in Gujarat accessions. The band with R_f value 0.28 was present only in Rajsamand and Barmer region of Rajasthan. The band with R_f value 0.36 was also restricted to Rajsamand region of Rajsathan. The bands with Rf values 0.23, 0.28 and 0.36 were absent in mother

plants of Gujarat whereas the bands with R_f value 0.47 and 0.6 were restricted only to Banas Kantha region of Gujarat.



Figure 56: Dendrogram showing genetic distances among 30 mother plants (15 from Rajasthan and 15 from Gujarat) generated by Isozyme marker studies.

Progeny studies of these 30 mother trees revealed that few mother plants are highly apomictic in nature and majorities are non-apomictic genotypes. Both types of genotype have their own role in germplasm conservation and improvement of this species.

5. Objectives met:

- I. Out of 33 districts of Rajasthan, Guggul distribution is in 33 districts as per SFD Rajasthan information available with us. A total of 2660 sample plots, 141 sites in 33 districts were surveyed covering 10294 hectare where Guggul occurrence has been recorded. In many sites male plants are totally lacking. Male plants were available in only at few places. Female and Male plants ratio was 99.9: 0.01. In other words male plants less than 0.01% in Rajasthan State.
- II. Germplasm collected for *ex situ* conservation from identified 117 CPPs. About 1428 vegetative cuttings with source details (GPS locations) were collected and raised in our vegetative propagation area for rooting. Differential response in sprouting and rooting was studied. Progenies of 10 CPPs are available to study apomixis behavior of these CPPs. DNA and Isozyme marker studies revealed that many of these CPPs produces genetically different progenies, which all the offspring's are not produced through apomixis. Marking of genotypes with high apomixis and poor apomixis are important tools for conservation and improvement of this species.
- III. Flowering and fruiting data also collected in every month at one site to study the phenological aspects and its annual pattern. Seeds were collected from six sources and 26 CPPs as mature seeds. Some genotypes have potential to produce high percentage of viable black seeds. Data analysis also indicates that location of genotype also playing important role in black and white seed ratios. Guidelines for seed germination in nursery bed developed (Annex. A).
- IV. Macropropagation studies are underway and data analysis of stem cuttings raised in mist chamber indicates that sprouting and rooting process do not have significant correlation. It appears genotype, physiological conditions and age of the source greatly influence the rooting process. January to April is ideal period of the year for rooting though rooting is possible in this species throughout the year. Guidelines for vegetative propagation framed.
- V. All the genotypes and progenies are characterized using DNA markers and are being maintained in field. Beside all these work guidelines prepared in Hindi which are attached as Annexure A and B.

Part II: Financial Progress

Total Budget of the Project: Rs. 17.00 Lakhs

Year	Grant released (Lakhs)	Expenditure (Lakhs)
2010-11	7.00	4.82
2011-12	4.62	4.64
2012-13	3.34	4.64
2013-14	2.04	2.90
Total	17.00	17.00

Years wise Budget relaesed and Utilization (Rupees in Lakhs):

Details of Project Staff recruited:

In this project one JRF and Field Assistant posts were approved along with the project proposal. Recruitment process was initiated immediately after release of budget. However, project staff (JRF and Field Assistant) joined the posts in September, 2010. Candidate's name, their Qualifications, date of joining is given below:

Name & Designation	Qualification	Date of appointment
Mr Rajesh Lomror Junior Researdch Fellow	M Sc Botany	September 13, 2010 to Nov. 2, 2011
Ms Hemshikha Tyagi Junior Research Fellow	M Sc Botany	June 15, 2012 to March 31, 2014
Rajendra Parihar, Field Assistant	B Sc Agriculture	September 16, 2010 to August, 2013

Enclosed

1. Utiliza	tion certificate
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2. Statement of Account

3. Certificate of non receipt of fund

Performa A Performa B

Date 8 May 2014

Dr (U.K. Tomar) PI Scientist F & Head

Proforma 'A'

FORMAT FOR UTILISATIONS CERTIFICATE

1

Form GFR 19-A (See Government of India's Decision (1) below rule 150) Form of Utilization Certificate

5. N	Letter No and date	Amount	Certified that out of Rs. 2.04lakhs (two lakhs four thousand rupees) of grant in aid sanctioned during the year 2013-2014 in favour of Director AFRI under the
1	F() silva/ 2013-14- 4482 Dated 11.12.13	204000/-	Ministry/Department letter No given in the margin and Rs Nil on account of unspent balance of the previous year, a sum of Rs2.04 lakhs has been utilized for the purpose of research for which it was sanctioned and that the balance of Rs nil/- remaining unutilized at the end of the year will be adjusted towards the grant in aid payable during the next year (As per books of accounts produced before us).

Certified that I have satisfied myself that the conditions on which the grant-in-aid was sanctioned have been duly fulfilled/are being fulfilled and that I have exercised the following checks to see that the money was actually utilized for the purpose for which it was sanctioned.

Date: Place: Jodhpur Kinds of checks exercised

- Before entering into liability prior approval of Director through HODs & Finance by respective divisions entrusted with the work is being obtained.
- 2. While procuring the material/equipment, normal government procedure has been followed strictly.
- 3. JRFs/Field assistants+ have been recruited as per ICFRE rules.
- 4. Payments to suppliers have been made after audit check by finance.
- Physical progress vio-a-vis financial progress of expenditure is being watched thoughout the period under report.

T.S.B.M

Signature S S) 4 Designation: Bipper 74594 ABID FORESTORER dhpunnstitute JODHPUR - 342 005

FORMAT FOR ANNUAL STATEMENT OF ACCOUNTS TO ACCOMPANY REQUEST FOR RELEASE OF NEXT INSTALLMENT (YEAR MEANS FINANCIAL YEAR *i.e* 1st April to 31st March OF NEXT YEAR)

- 1. Sanction letter No: F 16/2/212007/MP/PCCF/555-556 dated 18.03.2010
- 2. Total Project Cost:

3. Sanction/Revised Project cost (if applicable): Rs. 17.05 lakhs

17 lakhs

4. Date of Commencement of project: July, 2010

5. Statement of Expenditure

S .	Sanctioned/Heads	Funds	released			Expen	diture in	curred	and start	Balance	Remarks
N						1 4	Hung	111'	IVth	ason	
0		1 st year	ll nd year	llird year	IV year	Year	Year	Year	Year	(31.03.14)	
1	Equipment/Machine ry/Building	1.50	0.00	00	00	1.35	0.14	00	00	Nil	
2	Salary/Stipend/wag es	2.44	1.40	1.82	1.08	1.33	1.75	2.16	1.49	Nil	
3	Consumables										
4	TA/DA	1.00	1.20	0.38	.30	0.97	0.91	0.62	.43	Nil	
5	Conservation /Plantation/Nursery /QPM										
6	Training expenses							-			
7	Stationary & (publicity material)										
8	Monitoring	1		Received	1000-	10000	- 22.8075	- Contract	(income of		
9	Other expenses viz (marketing linkage buyer -seller meets etc please specify)	0.11	0.25	0.25	.20	Nil	0.36	0.23	.12	Nil	
10	Institutional charges	0.95	0.77	0.35	.15	0.75	0.60	0.60	0.28	Nil	
11	Contingencies	1.00	1.00	0.54	.31	0.41	0.89	1.03	0.58	Nil	
12	Total	7.00	4.62	3.34	2.04	4.81	4.65	4.64	2.90		

Signature of Principal Investigator with Date

Signature p And when with Date MATITUTE JODHPUR - 342 005

Signature of Author Auditor

with date gran an angelane treated Addis Forest Research Institute Contemp Jodhpur

CERTIFICATE OF NON-RECIEPT OF FUND

This is to certify that Arid Forest Research Institute Jodhpur is presently implementing the project No 106 entitled "Assessment of Guggul germplasm for studying population density, diversity, female and male plants ratio for in situ and ex situ conservation in Rajasthan" funded by State Forest Department Rajasthan. Organization has not received any financial assistance for the same work/purpose from central/state government department or any other agency.

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Annexure A

नर्सरी बेड में गुगल के बीज अंकुरण के लिए दिशानिर्देश

गुग्गुल (Commiphora wightii) बहुवर्षीय, बहुशाखीय एवं धीमी गति से बढ़ने वाला ब्रूसेरेसी कुल का झाड़ीनुमा वृक्ष है। उष्णकटिबंधीय एवं समशीतोष्ण क्षेत्रों में कोमीफोरा प्रजाति के पौधें अधिक पाएँ जाते हैं। भारत में राजस्थान , गुजरात, मध्य प्रदेश , तमिलनाडू एवं कर्नाटक इत्यादि प्रदेश में प्राकृतिक रूप से कोमीफोरा पाया जाता है। वर्तमान में गुगल राल की अत्यधिक औधोगिक मांग और इस पूर्ति के संबन्धित विनाशपूर्ण विदोहन के फलस्वरूप गुगल का भारत में विलुप्त वनस्पति प्राजातियों की श्रेणी में अंकित होना चिंतनीय है। गुगल पौधों की सुरक्षा एवं सरंक्षण के लिए प्रयास किया जाना चाहिए।

गुगल का प्रवर्धन बीज, कलम (कटिंग्स), गुटी एवं ऊतक संवर्धन विधि से किया जा सकता है। बीज से उत्पन्न मूसल जड़ पौधों की वृद्धि एवं विकास में उत्तम होती है। कलमों से उत्पन्न पौधों की तुलना में यह पौधा अधिक स्वस्थ एवं सहनशील रहता है। बीजों से गुगल के पौधों का प्रवर्धन कठिन है। प्रकृति में बहुत कम बीजों से नवोदभिद विकसित होते है। 1999 में यादव et al., ने इस प्रजाति में बहुत कम (5% से नीचे) बीज अंकुरण की सूचना दी। इसलिए यह महसूस किया गया कि इस पौधें में बीज अंकुरण का आंकलन करने के लिए कुछ मार्गदर्शी अध्ययन की आवश्यकता है।

इस पौधें का पुष्प निष्पादन वर्ष में दो (अप्रैल-जून एवं अक्टूबर-दिसम्बर) बार होता है। गुगल के फल वर्ष के अक्टूबर-नवम्बर एवं अप्रैल-मई महीनों में संग्रहित किये जाते है। प्रायः यह देखा गया है कि अप्रैल-मई महीनों में प्राप्त हुए बीजों का अंकुरण प्रतिशत अधिक होता है। बहुभ्रूणता के कारण इसमें एक बीज में से एक से चार नवोदभिद निकल सकते हैं। बीज चयन और अंकुरण प्रक्रिया- इसमें निम्नलिखित चरण शामिल है -:

1) बीज संग्रह :

- i. कोमीफोरा वाइटी के फल एक स्वस्थ, प्राकृतिक पेड़ से एकत्रित करते हैं।
- ii. परिपक्व फल मई-जून के दौरान एकत्रित करते हैं।
- iii. फल का हरे रंग से लाल रंग में बदलना परिपक्वता का सूचकांक है। पूर्ण परिपक्व फल गहरे लाल रंग का होता है (1 छवि)। यह बीज संग्रहण का सही समय है।



छवि. 1 गुगल का परिपक्व लाल फल

- 2) बीज प्रसंस्करण :
 - i. संग्रहण के बाद फलों को सूती कपड़े से रगड़कर उनका गुदा हटाया जाता है।
 - ii. गुगल में दो प्रकार (पीले-सफ़ेद व काले) बीज पाये जाते हैं। (छवि: 2 व 3)



छवि.2 गुगल के परिपक्व पीले-सफ़ेद बीज छवि. 3 गुगल के परिपक्व काले बीज

- गोले-सफ़ेद रंग के बीज अलाभकारी होते हैं। इनमें अल्पविकसित भ्रूण या भ्रूण के अभाव के कारण अंकुरण नहीं होता है।
- iv. काले रंग के बीज लाभकारी होते हैं। अतः इन्हें रोपण के लिए काम लिया जाता है।
- v. पीले-सफ़ेद बीजों को चुनना एक समय और श्रम गहन प्रक्रिया है। अतः इन्हें प्लवन तकनीक से हटाया जाता है। इस तकनीक में बीजों को 3-4 घंटे के लिए पानी में रखा जाता है।
- vi. काले रंग के बीज पानी में डूब जाते हैं (निमज्जक) जबकि पीले-सफ़ेद बीज पानी में तैरते रहते हैं (प्लवक)।
- vii. पीले-सफ़ेद बीजों को हटा दिया जाता है और काले बीजों को पात्र के निचले तले से एकत्रित किया जाता है।
- viii. बीजों को 2-3 दिनों के लिए हवा में सुखाया जाता है और अल्प मात्रा में बेविस्टिन मिलाया जाता है। फिर इन्हें वायुरोधी पात्र में सामान्य तापमान पर रखा जाता है।
- 3) बीज की बुवाई -

बीजों को बोने से पहले उन्हें एक घंटे नल के पानी के नीचे रखा जाता है।

- फिर बीजों को बेविस्टिन के घोल (100मिग्रा./100मिली.) में 30 मिनट के लिए रखा जाता है।
- ii. फिर इन्हें रेत माध्यम में बोया जाता है। इन्हें नियमित पानी देते हैं।
- iii. अधिकतर बीज बुवाई के बाद 6-17 दिनों के भीतर उग जाते हैं। बहुभ्रूणता के कारण कभी-कभी एक बीज से एक से अधिक पौधें उग सकते हैं।

बीज अंकुरण में समय बचाने के लिए और कम से कम समय अवधि में अधिकतम बीज प्राप्त करने के लिए यह जांच प्रक्रिया आवश्यक है। इस विधि से हम औसतन 40-50% तक बीज अंकुरण प्राप्त कर सकते हैं। यह देखा गया है कि विभिन्न क्षेत्रों में पीले-सफ़ेद और काले बीजों का अनुपात अलग है और यहा अनुपात एक ही क्षेत्र के विभिन्न पौधों में भी अलग-अलग है। चूंकि काले बीज में अधिक अंकुरण होता है इसलिए जिन क्षेत्रों में काले बीजों का अनुपात पीले-सफ़ेद बीजों की तुलना में ज्यादा हो उन्हें चिन्हित किया जाना चाहिए। अतः इस तकनीक के प्रयोग से गुगल के बीज अंकुरण में वृद्धि की जा सकती है।

अच्छे बीजो को अलग कर नर्सेरी मे उगाने की प्रक्रिया का प्रवाह चित्र



Annexure B

ध्ंध कक्ष में ग्गल के कायिक प्रवर्धन के लिए दिशानिर्देश

गुगल के संरक्षण एवं अत्यधिक उत्पादन के लिए कायिक प्रवर्धन तकनीक का उपयोग किया गया है जिसके दिशानिर्देश निम्न प्रकार हैं :-

- > सर्वप्रथम गुगल के 4-5 फीट लंबे स्वस्थ पौधों का चयन करना चाहिए।
- इन पौधों से एकत्रित कलमों को साफ पानी से धोकर, हल्के नम कपड़े में लपेटकर क्षेत्र से लाना चाहिए।
- 4-5 नोड वाली 1.5-2.0 सेमी. चौड़ी कलमों को 9 इंच लंबाई में काटकर इसके दोनों सिरों को 2% बेविस्टीन के घोल में 10-15 मिनट डूबाकर रखना चाहिए। इसके बाद इन कलमों को साफ पानी से धोकर कुछ देर सूखने देना चाहिए।
- इन कलमों को मोटी बजरी से भरी थैलियों में इस प्रकार लगाना चाहिए कि 2-3 नोड मिट्टी के अंदर रहें।
- इन कलमों को धुंध कक्ष में इस प्रकार रखा जाना चाहिए कि ये स्प्रिंक्लर के सीधे नीचे ना रहे जिससे कलमों का ऊपरी भाग पानी से ना भीगे और कवक संक्रमण को रोका जा सके। यदि मिट्टी कि थैलियों में ¼ इंच की गहराई तक नमी हो तो पानी देने की आवश्यकता नहीं है। इन कलमों में मूलोत्पत्ति के लिए किसी हार्मोन की आवश्यकता नहीं है यद्यपि कम सांद्रता पर हार्मोन (NAA 0.5 मिग्रा./ली. और IBA 0.5 मिग्रा./ली.) जड़ प्रेरण को बढ़ावा देता है।
- इस प्रकार इन कलमों की नियमित देखरेख से इनमें 20 दिनों बाद प्ररोह अंकुरण व 30-40 दिनों बाद जड़ प्रेरण प्राप्त किया जा सकता है।
- अधिकतम जड़ प्रेरण मार्च-अप्रैल एवं अधिकतम प्ररोह अंकुरण मार्च-जून माह में प्राप्त होता है।
- गुगल की कलमों को यदि एकत्रित करने के 2-3 दिन बाद मिट्टी में लगाया जाए तो अधिक प्ररोह अंकुरण एवं जड़ प्रेरण प्राप्त किया जा सकता है। इन कलमों का संग्रहण खुली छायादार जगह में करना चाहिए।
- अलग-अलग क्षेत्रों से एकत्रित कलमें जड़ प्रेरण के लिए विभिन्न प्रभाव दर्शाती हैं।
- कायिक प्रवर्धन तकनीक द्वारा तैयार पौधों बनाने मैं लगभग तीन माह लगते है। मिस्ट चेम्बर मैं तैयार पोधों को 1 महीने के लिए छायादार जगह पर रख कर हढ़ीकरण (Hardening) की जानी चाहिए और इसके बाद ये पौधें क्षेत्र में लगाने के लिए तैयार हो जाते हैं।

52

4-5 फीट लंबे स्वस्थ पौधों का चयन



एकत्रित कलमों को साफ पानी से धोना



4-5 नोड वाली 1.5-2.0 सेमी. चौड़ी कलमों को 9 इंच लंबाई में काटना



कलमों के दोनों सिरों को 2% बेविस्टीन के घोल में 10-15 मिनट डूबाकर रखना



कलमों को साफ पानी से धोकर कुछ देर सूखाना तथा IBA + NAA का नीचे वाले सिरे को ट्रीट करना



मोटी बजरी से भरी थैलियों में लगाना एवं ध्ंध कक्ष में रखना



20 दिनों बाद प्ररोह अंकुरण व 30-40 दिनों बाद जड़ प्रेरण



 महीने छाया कक्ष में रखना तत्पश्चात क्षेत्र रोपण