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1. DIRECTOR'S INTRODUCTION

A brief historical introduction

The Indian Lac Research Institute, Ranchi, which was set up in 1925, continued to function under the administrative control of the Indian Council of Agricultural Research, New Delhi w.e.f. April 1, 1966. The Institute is located at Namkum, about nine kilometres east of Ranchi. Out of a total area of about 49 ha, nearly 35 ha are being used as plantation for cultivation experiments. Areas/trees have been taken on long term lease for outstation experiments.

Objectives

The objectives of the Institute are:

1) To carry out research towards affecting improvements in the cultivation, processing and standardization of lac and study its constitution and modifications so as to intensify lac production and extend its utilization,

2) To extend the results of research through publicity, maintaining liaison with and providing technical service to the growers and indigenous industries towards increased utilization of lac and improving the quality of their products, and

3) To impart training in improved methods of lac cultivation and industrial uses of lac.

Organizational set-up

The Institute consists of five Divisions, namely, Entomology, Agronomy and Plant Genetics, Chemistry, Technology, and Extension. The Institute Library adjoins the Entomology division. Besides these, the Institute has Administrative, Audit and Accounts, Artist-cum-Photography, and Mechanical Sections. The Institute maintains one Regional Field Research Station at Dharamjaigarh (M.P.) and also runs one Operational Research Project in a group of four villages in Ranchi District to demonstrate the package of practices for improving the production of lac on area basis.

The overall administrative and technical supervision of the Institute is done by the Director. The Divisions of Chemistry and Entomology are headed by their respective Head of Division, while the remaining Divisions are under the charge of their respective seniormost Scientist.

Research Highlights

Entomology

In entomological research, the notable results included: (i) the relative abundance of lac pests differs with the lac insect strain and the season but not with the lac hosts tried; the *rangeeni* crops are more susceptible to pest losses

than the *kusmi*, (ii) the monoecious variety of *putri* (*Croton oblongifolius*) has shown promise as a lac host for raising the *aghani* crop, (iii) studies made on microorganisms harboured by the lac insects have suggested their symbiotic role, (iv) the pest control schedule involving the use of Thiodan® and Thuricide® does not adversely affect the lac insects, (v) varying the time of crop inoculation is found to affect the pest incidence which information could now be used for devising a cultural method of pest control, and (vi) the field demonstrations given under the Operational Research Project have shown that the lac yield can be increased to 2·7 times by adopting the improved method of lac cultivation.

Agronomy and Plant Genetics

Studies on the use of plant growth regulators have provided useful information for quick establishment of *bhalia* and *galwang* bushes for intensive lac cultivation.

Chemistry Division

A spectronic method which depends on finding the absorption maxima (λ_{max}) of the alkaline solution of 2:4-dinitrophenyl hydrazone of water soluble acids has been evolved for the estimation of aldehydic (jalaric/*lacci*-jalaric) acids in lac. It may form the basis for the estimation of shellac in presence of other resins.

A lac based insulating varnish has been prepared by reacting shellac and double boiled linseed oil in presence of litharge and lime as incorporating agents which give a breakdown strength 3 kV/mil indicating that it can be used as a high grade baking type insulating varnish and produces hard, smooth and non-tacky films.

Technology Division

When a blend of epoxy resin (epikote 100) and shellac (1:1) was heated at 100°C for 30 min, the bond strength was found to increase to 0·56 ton/sq inch as compared to 0·08 ton/sq inch of plain shellac.

Library

The number of books and bound volumes of journals accessioned during the period was 292. This brought the total number of books and volumes of journals in the library to 16,511. One hundred fifty-two periodicals were subscribed in addition to a few received in exchange or as gift. Some miscellaneous publications and reports were also received.

The library also maintains an adequate stock of books and reprints of articles published by the Institute and by the erstwhile Indian Lac Cess Committee for sale/distribution to those interested.

Visitors

The Institute has always been a regular attraction to most visitors to Ranchi, particularly Scientists and Technologists. During the period under report also, it received the usual complement of visitors including students

and trainees from different colleges and institutions, officials, delegates and other distinguished persons. These included, among others, the following:

1. Sri Jagdambi Prasad Yadav, Union Minister of State for Health and Family Welfare, Govt. of India.
2. Dr Malcom Ice, Dept. of Zoology, Oxford University, U.K.
3. Miss Norma C. Tagaza, Odenauer Foundation, Bangkok, Thailand.
4. Maj. Gen. H. S. Seth, Eastern Command, Indian Army.
5. Sri S. S. Dhanoa, I.A.S., Secretary, ICAR, New Delhi.
6. Prof. Feni Dumont, Paris, France.
7. Sri R. Raymolds, Ford Foundation, New Delhi.
8. Sri S. C. Pandey, Industrial Adviser (Chemicals), Small Industries Development Organization, Govt. of India, New Delhi.
9. Sri K. M. Thakur, Managing Director, Ranchi Industrial Area Development Authority.
10. Sri J. P. Nautiyal, Director of Horticulture, Ministry of Agriculture, New Delhi.
11. Sri Baldev Rai, Director, Audit and Accounts, ICAR, New Delhi.
12. Dr K. G. Tejwani, Director, Central Soil and Water Conservation Research and Training Institute, Dehradun.

Training and advisory services

The Institute provides two courses of training of six-month duration each on (i) Improved methods of lac cultivation and (ii) Industrial uses of lac. The training is given to deputees of Central and State Governments and Industrial Undertakings. In addition, short term training on specific lines is also arranged on request.

The Institute also provides technical assistance to all those interested in cultivation, processing, grading and utilization of lac.

Research collaboration overseas and with other institutions

The Institute has always sought to take advantage of technical know-how and facilities available in other Institutions/Universities for the furtherance of its objectives, in particular for the evaluation of the products and processes developed at the Institute.

The Institute is represented in the Lac Development Council, Shellac Export Promotion Council and Technical Committee of the Indian Standards Institution.

Finance

The Institute is being wholly financed by the Indian Council of Agricultural Research. The budget estimates of the Institute for the year 1977 amounted to Rs. 25·21 lakhs for Non-Plan and Rs. 6·00 lakhs for Plan Scheme. The actual expenditure during the year was Rs. 22·96 lakhs and Rs. 4·25 lakhs under Non-Plan and Plan respectively. In ddition, an amount of Rs. 0·57 lakh was spent under Operational Research Project and Rs. 0·52 lakh under A. P. Cess Scheme on " Cultivation of *kusmi* lac on *bhalia* and *galwang* in mixed plantation at Chandwa ".

2. PROGRESS OF RESEARCH

A. ENTOMOLOGY DIVISION

(a) RESEARCHES COMPLETED

1.1 Lac Cultivation Studies

1.1.1 A comparative study of different techniques of lac cultivation on *kusum* (*Schleichera oleosa*) at Hesal

The study was undertaken to evolve an improved cultivation schedule for *kusmi* lac on its principal host, *kusum*. Three cultivation practices tried were as follows:

(i) The new 2-coupe system involving crop inoculation on 12-month-old shoots in July with partial harvesting of the *aghani* crop in January/February and raising the self- and artificially inoculated *jethwi* crop on 18-month-old shoots with complete harvesting of the crop in July next (treatment A),

(ii) The standard 4-coupe system evolved earlier involving crop inoculation on 18-month-old shoots and complete harvesting in each crop season (treatment B), and

(iii) The villagers' practice of taking repeated partial crops in each crop season (treatment C).

The experiment was laid out on a randomized block design.

The crop data are presented in Table 1.

It is observed that treatment 'B' (standard 4-coupe system) has shown the best performance, followed by treatment 'A' (2-coupe system).

(R. S. Gokulpure and R. C. Maurya)

1.3 Ecological Studies on Lac Insects and Associated Insects

1.3.1 Relative dominance of the inimical and beneficial insects associated with lac insect in different seasons on different lac host plants

This project was undertaken to study the relative abundance of various inimical and beneficial insects associated with lac insects in different seasons on different host plants. For this study, *rangeeni* lac insects were cultured on *palas* (*Butea monosperma*) and *bhalia* (*Moghania macrophylla*), and *kusmi* on *kusum* (*Schleichera oleosa*) and *bhalia*, during 3 crop seasons at ILRI plantation. *Bhalia* was used throughout for *katki* and *aghani* crops but for *baisakhi* and *jethwi*, it was continued only for 2 years as it was found to be a poor host of summer crops. The lac insects were cultured for each crop in 3 replicated sets, each of 14 trees of *palas*, 9 of *kusum* and 34 bushes of *bhalia* for *kusmi* crops and 40 for *rangeeni* except *katki* crop where the number of host plants was

TABLE 1 — CROP DATA UNDER DIFFERENT CULTIVATION PRACTICES TRIED ON *kusum* AT HESEL DURING 1972 TO 1977 SEASONS

Treatment	Crop	No. of trees	Brood used (kg)		Yield (kg)		Crop ratio*
			Lac stick	Stick lac	Lac stick	Stick lac	
A	*Aghani* 1972-73-*cum-jethwi* 1973	10	40·80	17·90	487·85	166·30	1:8·45
	Aghani 1973-74-*cum-jethwi* 1974	39	95·00	27·30	443·75	72·40	1:2·60
	Aghani 1974-75-*cum-jethwi* 1975	39	115·00	37·34	277·70	32·88	1:0·88
	Aghani 1975-76-*cum-jethwi* 1976	20	67·00	22·85	300·65	91·15	1:3·90
	Aghani 1976-77-*cum-jethwi* 1977	36	194·50	74·59	743·70	166·04	1:2·22
	Total	144	512·30	179·98	2253·65	528·77	
	Mean		102·46	33·99	450·73	105·75	1:2·94
B	*Aghani* 1972-73-*cum-jethwi* 1973	10	40·80	19·00	485·80	167·50	1:8·81
	Aghani 1973-74-*cum-jethwi* 1974	26	95·00	27·60	460·40	92·10	1:3·30
	Aghani 1974-75-*cum-jethwi* 1975	26	114·50	34·36	290·25	49·21	1:1·40
	Aghani 1975-76-*cum-jethwi* 1976	16	57·10	20·89	215·80	57·96	1:2·70
	Aghani 1976-77-*cum-jethwi* 1977	24	126·60	47·45	542·70	156·52	1:3·29
	Total	102	434·00	149·30	1994·95	523·29	
	Mean		86·80	29·86	398·99	104·66	1:3·50
C	*Aghani* 1972-73-*cum-jethwi* 1973	10	40·70	20·70	134·70	47·20	1:2·52
	Aghani 1973-74-*cum-jethwi* 1974	13	45·00	9·30	The crop being poor left for self inoculation		
	Aghani 1974-75-*cum-jethwi* 1975	13	95·00	20·34	153·95	21·72	1:1·60
	Aghani 1975-76-*cum-jethwi* 1976	12	57·45	22·16	61·30	22·78	1:1·03
	Aghani 1976-77-*cum-jethwi* 1977	12	26·00	9·36	119·50	24·75	1:2·60
	Total	60	264·15	81·86	469·45	116·45	
	Mean		52·83	16·37	93·89	23·29	1:1·42

*Crop ratio refers to the ratio of yield to brood lac used in terms of stick lac.

reduced to half of *baisakhi* crop due to shorter duration of the crop, and consequently less number of samples were drawn. One sample of 500 g lac sticks drawn at random from each replicated set of each crop was collected fortnightly from the time of *phunki* removal till the crop harvesting. These sticks were caged in the laboratory for recording the emergence of insects.

The data obtained from this study (Tables 2 and 3) clearly show that the numbers of parasites and predators of lac insects collected from *rangeeni* insects were distinctly more than that from *kusmi*. Higher numbers of predators were recorded in *baisakhi* and *jethwi* crops than *katki* and *aghani*, respectively. The number of inimical parasites was maximum in *baisakhi* crop due to remarkably higher number of *Tetrastichus purpureus* (Cam.) in this crop, otherwise the total number of other parasites was higher in *katki* and *aghani* crops. The beneficial parasites were predominantly numerous in *katki* and *aghani*. It has also been consistently found that *T. purpureus* and *Tachardiaephagus tachardiae tachardiae* (How.) were the most abundant parasites of lac insects in all the crops. The number of other parasites, such as, *Parechthrodryinus clavicornis* (Cam.), *Coccophagus tschirchi* Mahd., *Eupelmus tachardiae* (How.) and *Erencyrtus dewitzi* (Mahd.) failed to reveal a consistent and well marked picture of their abundance due to their low and fluctuating numbers. *C. tschirchi* was notably abundant in *Katki* crop whereas *Tachardiaephagus tachardiae somervillei* (Mahd.) was recorded only from *kusmi* lac insects. *Marietta javensis* (How.) appeared in extremely low numbers. The relative abundance of the major lac predators differed with the two strains of lac insects in that while *Eublemma amabilis* Moore was most abundant on *rangeeni* insects, *Holcocera pulverea* (Meyr.) dominated on *kusmi*. *Chrysopa* sp. appeared most casually in low number and only from *kusmi* insects. *Bracon greeni* Ashm. was the most abundant parasite of lac predators, followed by *Apanteles tachardiae* Cam., *Pristomerus sulci* Mahd. and Kalub., *Brachymeria tachardiae* (Cam.) and *Apanteles fakhrulhajiae* Mahd. which did not show a consistent and well marked trend of their relative abundance just like some of the parasites of lac insects as mentioned above. *Elasmus claripennis* Cam. was notably abundant in *katki* and *aghani* crops. The trend

TABLE 2 — NUMBER OF VARIOUS GROUPS OF INSECTS (ADULTS) ASSOCIATED WITH LAC INSECTS IN RELATION TO THEIR STRAINS AND CROPS

(*Total numbers for* 3 *crop seasons*)

Lac insects		Inimical parasites	Predators	Beneficial parasites
Strains	Crop			
Rangeeni on *palas*	*Katki*	3134	600	295
	baisakhi	4372	936	137
	Total	7506	1536	432
Kusmi on *Kusum*	*Aghani*	2257	270	422
	jethwi	893	304	97
	Total	3150	574	519

TABLE 3 — RELATIVE ABUNDANCE OF VARIOUS INSECTS (ADULTS) ASSOCIATED WITH LAC INSECTS

Lac insect		*(Total numbers for 3 crop seasons)*																
		Inimical parasites								Predators			Beneficial parasites					
Strain	Crop season	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)
Rangeeni	*Baisakhi on palas*	3655	331	261	32	59	29	5	—	609	327	—	86	23	15	3	9	1
	Katki on palas	1507	695	307	378	228	16	3	—	429	171	—	114	74	15	4	85	—
	Katki on bhalia	702	636	239	335	265	—	1	—	263	51	—	49	6	15	—	46	1
Kusmi	*Jethwi on kusum*	521	246	21	9	89	6	—	1	70	229	5	65	21	4	6	1	—
	Aghani on kusum	1395	455	63	40	43	127	2	132	106	159	5	297	36	54	—	14	21
	Aghani on bhalia	1081	474	61	29	35	37	1	2	152	103	2	287	26	15	—	82	1

Legends: 1 — *T. purpureus*, 2 — *T. tachardiae tachardiae*, 3 — *P. clavicornis*, 4 — *C. tschirchi*, 5 — *E. dewitzi*, 6 — *E. tachardiae*, 7 — *M. javensis*, 8 — *T. tachardiae somervillei*, 9 — *E. amabilis*, 10 — *H. pulverea*, 11 — *Chrysopa* sp., 12 — *B. greeni*, 13 — *A. tachardiae*, 14 — *P. sulci*, 15 — *B. tachardiae*, 16 — *E. claripennis*, 17 — *A. fakhrulhajiae*.

of relative abundance of these insects did not vary much with the hosts tried. While the abundance of the inimical parasites was high at about the time of sexual and crop maturity, that of predators was at its peak only during crop maturity. It was also found that population of the main predators was regulated by their main parasites.

(B. P. Mehra and D. C. Srivastava)

1.5 Breeding and Genetical Studies on Lac Insects

1.5.6 Further studies on the genetic system in lac insects

Earlier tests using the colour genes had confirmed an unorthodox chromosomal system in the Indian lac insect, *Kerria lacca* (Kerr), but unlike the 'Lecanoid' system, the male was found to express the paternal allele (A.R.: 1974-76). The somatic activity of paternal chromosomes was further tested through radiation analysis.

The male lac insects, soon after their emergence from the lac cells, were X-irradiated at 2000 r and each mated to a virgin female. The resulting progenies were maintained individually for study of sex ratio.

It will be seen from Table 4 that, although the progeny size was considerably reduced with the paternal X-irradiation, the sex ratio remained more or less unaffected. Thus, the dominant lethality induced through paternal irradiation affected equally the sons and the daughters, providing additional evidence that the paternal genetic effects are, indeed, expressed in the male lac insect. Thus, although an unorthodox genetic system is confirmed for *K. lacca*, it is found to differ from 'Lecanoid' system in gene expression.

TABLE 4 — COMPARISON OF SEX RATIO IN THE PROGENIES DERIVED FROM THE X-IRRADIATED AND UNTREATED MALE LAC INSECTS

	Number of progenies	Daughters	Sons	Sons %
With paternal X-irradiation	11	395	140	26·2
With untreated parents	14	1064	433	28·9

(N. S. Chauhan and Jawahirlal)

(b) RESEARCHES ON HAND

1.1 Lac Cultivation Studies

1.1.2 Studies to evolve a suitable method for producing lac on *bhalia* (*Moghania macrophylla*) regularly during both the seasons

(i) *At Hesal*

The seven cultivation practices studied earlier (A.R.: 1974-76) remained under field trial with 10 replications, each having 5 bushes. Inoculation was made on one-year-old shoots during February 1976. The crop yield of *jethwi* 1976-*cum-aghani* 1976-77 is presented in Table 5.

TABLE 5 — CROP PERFORMANCE UNDER THE DIFFERENT CULTIVATION PRACTICES TRIED ON *bhalia* AT HESAL DURING *jethwi* 1976-*cum-aghani* 1976-77

Treat-ments	Brood used (kg)		Yield (kg)						Crop ratio*
			Ari		Mature		Total		
	Lac stick	Stick lac	Lac stick	Stick lac	Lac stick	Stick lac	Lac stick	Stick lac	
A	20·0	9·45	34·80	3·85	—	—	34·80	3·85	1:0·40
B	10·0	4·99	3·51	0·47	22·0	4·48	25·51	4·95	1:0·99
C	5·0	2·20	0·82	0·09	27·85	5·26	28·67	5·35	1:2·42
D	2·5	1·29	—	—	24·10	4·50	24·10	4·50	1:3·49
E	20·0	9·90	—	—	34·70	4·72	34·70	4·72	1:0·47
F	5·0	2·49	1·10	0·11	20·55	3·72	21·65	3·83	1:1·54
G	2·5	1·40	—	—	21·30	3·40	21·30	3·40	1:2·42

*Crop ratio refers to the ratio of yield to brood lac used in terms of stick lac.

It is seen that the performance of treatment D (50 g brood lac/bush) was best, followed by that of treatment C (100 g brood lac/bush) in respect to lac yield per kg brood used.

Foliar spray with urea did not result in the increase of yield.

(R. S. Gokulpure and R. C. Maurya)

(ii) *At Amjharia*

This experiment was continued as per the layout reported earlier (A.R.: 1974-76) with a slight modification that the brood rate in treatment B-3 was 300 g per bush instead of 400 g. There were 5 bushes under each treatment with 10 replications. All the bushes of *bhalia* under different treatments were inoculated in January 1976. The crop performance for *jethwi* 1976-*cum-aghani* 1976-77 is shown in Table 6 and may be summarized as follows:

(i) Highest lac yield was obtained from the lowest bood rate applied.

(ii) Cultural practice T_3 has been found to be superior to other practices tried. This confirms the finding of the previous year.

(iii) Due to the interaction of brood rate and cultural practice, B_2T_3 came out to be the best.

TABLE 6 — CROP PERFORMANCE UNDER DIFFERENT CULTIVATION PRACTICES TRIED ON *bhalia* (*Moghania macrophylla*) AT AMJHARIA

(Crop: *jethwi* 1976-*cum-aghani* 1976-77)

Cultural practice	Brood rate :	Stick lac yield (kg)/crop ratio			
		B_1	B_2	B_3	Mean
T_1		2·500	4·100	6·600	4·400
		1:0·88	1:0·84	1:0·95	1:0·89
T_2		4·250	5·455	4·255	4·653
		1:1·61	1:1·08	1:0·57	1:1·08
T_3		3·245	6·890	7·170	5·768
		1:1·12	1:1·34	1·0·93	1:1·13
T_4		2·400	3·550	5·450	3·800
		1:0·88	1:0·71	1:0·73	1:0·77
T_5		2·600	2·375	5·050	3·341
		1:0·93	1:0·48	1:0·69	1:0·70
Mean		2·999	4·474	5·705	
		1:1·08	1:0·49	1:0·77	

(R. S. Gokulpure and P. Sen)

1.1.3 Evolution of a schedule for *rangeeni* lac cultivation on *galwang* and *ber* in alternation

The experiment was continued as per the lay out reported earlier (A.R.: 1974-76) with 2 bushes under each sub-plot treatment replicated 5 times using *ber* and *galwang* for raising *katki* and *baisakhi* crops respectively.

The crop performance was compared with that on the conventional *rangeeni* host, *palas*, where the crop ratios during *baisakhi* 1976-77 and *katki* 1977 were 1 : 5.10 and 1 : 0.35 respectively.

The experiment was conducted on 90 bushes each of *ber* and *galwang* respectively and protective sprays of 0.05% Thiodan® were applied during both the *rangeeni* crops. The crop data for *baisakhi* 1976-77 and *katki* 1977 are presented in Tables 7 and 8 respectively and may be summarized as under:

In *baisakhi* 1976-77 crop on *galwang*, (i) the highest yield of stick lac was obtained from the lowest brood rate applied. This confirms the findings of the earlier year, (ii) there has been slight increase in yield by soil application of fertilizer and (iii) as a result of interaction between the brood rate and application of fertilizers, the performance of B_1F_2 was found to be better.

In *katki* 1977 crop on *ber*, (i) medium brood rate (B_2) proved to be better, (ii) soil application of fertilizer (F_2) slightly increased the yield and (iii) as a result of interaction between the brood rate and fertilizer application, B_2F_2 emerged out to be the best.

Further inoculation were made for *baisakhi* 1977-78 and the crop was progressing satisfactorily.

TABLE 7 — CROP DATA FOR *baisakhi* 1976-77 ON *galwang*

Fertilizer application	Brood rate :	Stick lac yield (kg)/crop ratio			
		B_1	B_2	B_3	Mean
F_1		0·375	0·540	0·565	0·493
		1 : 1·07	1 : 1·74	1 : 1·04	1 : 1·28
F_2		0·440	0·310	0·550	0·433
		1 : 2·09	1 : 1·03	1 : 1·07	1 : 1·40
F_3		0·460	0·350	0·450	0·420
		1 : 1·70	1 : 1·12	1 : 0·76	1 : 1·19
Mean		0·425	0·400	0·522	
		1 : 1·62	1 : 1·30	1 : 0·96	

TABLE 8 — CROP DATA FOR *katki* 1977 ON *ber*

Fertilizer application	Brood rate :	Stick lac yield (kg)/crop ratio			
		B_1	B_2	B_3	Mean
F_1		1·230	1·410	1·750	1·463
		1 : 2·19	1 : 1·70	1 : 1·46	1 : 1·78
F_2		1·075	2·020	1·950	1·682
		1 : 1·79	1 : 2·33	1 : 1·65	1 : 1·92
F_3		0·875	1·380	1·300	1·185
		1 : 1·37	1 : 1·48	1 : 1·17	1 : 1·34
Mean		1·060	1·603	1·660	
		1 : 1·78	1 : 1·84	1 : 1·43	

(R. S. Gokulpure and P. Sen)

1.1.5 Finding out the alternate hosts for *kusmi* and *rangeeni* strains of lac insects under field conditions

A. *Kusmi* strain

During the period under report, 3 hosts were studied for raising *jethwi* 1977 and *aghani* 1977-78 crop. These are *putri* (*Croton oblongifolius*), *bariyari* (*Desmodium pulchellum*) and *gorai* (*Millettia extensa*). The data collected are presented in Table 9.

Out of the above three hosts, only monoecious variety of *putri* (*C. oblongifolius*) produced *aghani* 1977-78 crop. The other hosts did not produce any satisfactory crop.

B. *Rangeeni* strain

During the period under report in addition to the three hosts tried for *kusmi* strain, one additional host *gursikri* (*Grewia hirsuta*) for raising *baisakhi* 1976-77, *katki* 1977 and *baisakhi* 1977-78, was included.

Results presented in Table 9 indicate that more trials on *putri* and *bariyari* are required.

(R. S. Gokulpure and P. Sen)

1.2 Physiological Studies on Lac Insects and Associated Insects

1.2.1 (b) Nutritional requirements of the predators, *Eublemma amabilis* and *Holcocera pulverea* and evolution of a suitable artificial diet

Laboratory culture of the lepidopterous predators of lac insect is essential for a regular supply of the predatory larvae required for various studies particularly with respect to their control.

Previous experiments showed that the artificial diets prescribed for other lepidopterous larvae, used as such or fortified with either scraped lac or dried and pulverized lac insects, were inadequate for proper growth and development of the larvae of *Eublemma amabilis* Moore. Hence a probe into the exact nutritional requirements of these larvae through qualitative and quantitative assay of the biochemical moieties of their natural food was undertaken.

In these attempts, chromatographic analysis and estimation of the total fat and amino acids respectively of lac insect body and trials of different formulations of artificial diets fortified with the extracts were made on the laboratory hatched first instar larvae of *E. amabilis*.

Extraction of the lipoidal substances was done with chloroform: methanol (2:1 v/v) using Soxhlet extraction technique at 80°-90°C over water bath for one hour followed by removal of the solvent at the same temperature. Subsequently the mixture of the fatty matters obtained was chromatographed with different solvent systems, viz., (i) petroleum ether : diethyl ether : acetic acid (90:90:1 v/v/v); (ii) petroleum ether: diethyl ether (92:8 v/v); (iii) hexane: diethyl ether: acetic acid (90:10:1 v/v/v); (iv) petroleum ether: diethyl ether: acetic acid (94.5:5:0.5 v/v/v), (v) petroleum ether: diethyl ether: acetic acid (80:20:1 v/v/v) and (vi) chloroform: methanol: water (80:25:3 v/v/v). Iodine vapour, antimony trichloride in chloroform and potassium dichromate in H_2SO_4 were used as visualizing agents. The above experiments showed that the lipoidal matters so obtained from lac insects contained at least 10 components

TABLE 9 — CROP DATA FOR LAC CULTIVATION TRIALS ON SOME NEW LAC HOSTS

Crop	Name of host	No. of plants	Total quantity of brood used (kg)	Wt of phunki scraped (kg)	Yield of lac stick (kg)	Yield of stick lac (kg)	Crop ratio	Remarks
Baisakhi 1976-77	*Croton oblongifolius*	15	4·200	0·450	—	—	—	Left for self-inoculation in July 1977 as the resultant crop was very poor
do	*Desmodium pulchellum*	50	2·000	0·210	9·600	1·320	1:6·28	
do	*Millettia extensa*	4	1·000	0·100	3·300	0·450	1:4·50	
do	*Grewia hirsuta*	3	1·000	0·100	—	—	—	do
Katki 1977	*C. oblongifolius*	15	4·800	1·800	7·000	1·220	1:0·67	
do	*D. pulchellum*	30	1·000	0·400	3·000	0·350	1:0·87	
do	*M. extensa*	5	1·600	0·060	—	—	—	Failed to produce any crop
do	*G. hirsuta*	3	0·200	0·010	0·400	0·025	1:2·50	Self-inoculation in July 1977 failed to produce any crop
Jethwi 1977	*C. oblongifolius*	25	3·800	2·370	9·200	2·360	1:0·99	Only 9 plants produced crop
do	*D. pulchellum*	100	2·000	0·950	—	—	—	Failed to produce any crop
do	*M. extensa*	34	1·700	0·750	—	—	—	Left for self-inoculation in July 1977
Aghani 1977-78	*C. oblongifolius*	50	9·800	3·800	—	—	—	A fair crop was progressing till the end of December 1977
do	*D. pulchellum*	50	2·000	0·800	—	—	—}	Failed to produce any crop
do	*M. extensa*	34	1·600	0·650	—	—	—}	

having different R_f values. Quantitative separation and identification of the components are yet to be made.

Quantitative assay of the total free amino acids was also done gravimetrically from fat-free aqueous homogenates of the lac insects by the use of cation exchange resin and dilute solution (5N) of ammonium hydroxide and subsequent evaporation over water bath at 90°C. It was found that immature stages of lac insects contained approximately 2·955 g of crude free amino acids per 100 g of dry lac insects.

Further attempts were also made to rear the predatory larvae on artificial diets consisting of agar agar, peptone, casein, glycogen, galactose and Wesson's salt fortified with the lipoidal matters and amino acids obtained from lac insect homogenate which, however, did not succeed much in respect of growth and development, though the newly hatched larvae of *E. amabilis* accepted the diet as evidenced by their typical tunnelling habit and production of excreta.

(T. P. S. Teotia, A. K. Sen and A. H. Naqvi)

1.2.2 Evolution of a suitable synthetic diet for artificial rearing of lac insects

In order to bring about improvements in the artificial substrate for providing better surface texture to lac larvae to moult, various trials were undertaken with different concentrations ranging from 3 to 5 per cent of shred agar slants at varying preservation temperature. Thirty lac larvae per slant replicated 4 times were used for this study.

During *jethwi* 1977 season, shred agar slants prepared in double distilled water in the concentration of 3-4 per cent and preserved at 4°C for two weeks prior to settlement were used to rear lac larvae. Although the shred agar served as the best substrate for settlement and survival, lac larvae failed to moult. In the rearing trials using synthetic/artificial diets D_1 (amino acids, vitamins, mineral salts, sucrose and water) and D_{15} (water extract of *bhalia* with 2% sucrose), it was observed that the initial settlement of lac larvae, rate of growth and development, and extent of resin secretion were considerably improved up to 40 days.

During *katki* 1977 and *baisakhi* 1977-78 seasons, rearing trials were continued on the improved substrates of shred agar soaked with diets D_1 and D_{15}. While diet D_1 recorded maximum survival of lac larvae ranging from 30 to 50% for a period of 61 and 110 days during *katki* and *baisakhi* seasons respectively, as compared to 36 and 57 days during corresponding period of the previous year, D_{15} showed maximum survival during *katki* and *baisakhi* crops seasons up to 36 and 32 days as against previous corresponding figures of 31 ad 55 days.

(A. H. Naqvi and T. P. S. Teotia)

1.2.3 Studies on the role of microorganisms present in lac insects

Trials were continued during the year to confirm the findings reported earlier that microorganisms harboured by the lac insects have some role in their nutrition.

The synthetic diet containing chloromycetin (250 mg in 100 ml of the diet) was fed artificially to lac larvae in the laboratory. The effect of the antibiotic on the lac larvae was quite pronounced approximately 18 hr after feeding as evidenced by unhealthy, thin and slender appearance of the body and non-

production of white waxy filaments. Mortality of such lac larvae occurred within 48-72 hr of feeding, suggesting that association of the microorganisms with lac insects is of symbiotic nature and that destruction of microorganisms present in the body of lac larvae causes acute nutritional deficiency ultimately causing total mortality.

Further work was also continued for the isolation of microorganisms from lac insects reared on *arhar* and *galwang*. On the basis of morphological and cultural tests it was found that the lac insects grown on these two hosts also harboured all the four different species of microorganisms, namely, *Micrococcus conglomeratus*, *M. coccus*, *Bacillus subtilis* and *Clostridium* sp., which were reported in the case of the major lac-hosts.

(A. H. Naqvi)

1.3 Ecological Studies on Lac Insects and Associated Insects

1.3.2 Effect of host density and age of host on the incidence of predators in different crop seasons

The objective and technical programme of the study have been reported earlier (A.R.: 1974-76).

Data on the incidence of the two lepidopterous predators from various crops on different host species are presented in Table 10. It was observed that the heaviest infestation of *Eublemma amabilis* and *Holcocera pulverea* occurred on highest density, except in *aghani* 1977-78 on *kusum* where it was inconsistent in case of both the predators recorded at *phunki* removal, and only that of *E. amabilis* on *bhalia* at sexual maturity in the treatment where brood rate was 50 g per bush. These results indicate that with the increase of broodlac for varying the density of population of the lac insect, population of both the predators increased except in a few cases as mentioned above.

(B. P. Mehra and B. N. Sah)

1.3.3 To study the bio-ecological aspects of *Pristomerus sulci* an endoparasite of *Holcocera pulverea*, a predator of lac insect

The mating technique developed earlier was repeated by keeping the two sexes in different ratios for 24 hr, 48 hr and 72 hr. The data are presented in Table 11, from which it was observed that mating took place in only such cases where the ratio of male to female was 1:3; 2:1 and 3:1; but when the ratio of male to female was 1:1 and 1:2, mating did not take place. Thus, it was found that a ratio of 2 males:1 female and 72 hr holding time were most appropriate for mating.

(B. P. Mehra and M. L. Bhagat)

1.3.4 To study the effect of insecticidal control of the major lac predators on the vital and economic attributes of the lac insect and on its associated fauna

The objective and the technical programme of the study have been detailed earlier (A.R.: 1974-76). However, a slight modification was made in that the first spray in *aghani* crop consisted of spraying with endosulfan (Thiodan®) only.

The data are presented in Table 12 from which it may be seen that the control schedule using endosulfan (Thiodan®) and *Bacillus thuringiensis* (Thuri-

TABLE 10 — INCIDENCE OF THE MAJOR PREDATORS (ALL STAGES) IN RELATION TO THE AGE AND DENSITY OF THE LAC INSECTS

Crop	Host	Rate of brood lac (kg)	At phunki removal		At third moult		At crop maturity	
			Eublemma amabilis No.	*Holcocera pulverea* No.	*Eublemma amabilis* No.	*Holcocera pulverea* No.	*Eublemma amabilis* No.	*Holcocera pulverea* No.
Jethwi 1977	*Kusum*	0·250	83	Nil	74	2	20	5
		0·500	139	3	172	9	41	14
		1·000	157	6	224	17	64	18
		2·000	167	8	311	33	89	26
Aghani 1977-78	*Kusum*	0·250	227	79	29	6	—	—
		0·500	157	27	30	8	—	—
		1·000	432	177	36	18	—	—
		2·000	313	81	38	22	—	—
	Bhalia	0·025	31	2	29	6	—	—
		0·050	41	5	22	7	—	—
		0·100	98	8	26	11	—	—
		0·200	145	14	30	11	—	—
Katki 1977	*Palas*	0·125	109	13	70	23	9	2
		0·250	117	35	112	37	13	3
		0·500	184	65	199	55	33	9
		1·000	228	67	336	98	91	39
	Bhalia	0·025	31	3	56	7	3	1
		0·050	45	8	84	14	5	2
		0·100	109	16	108	28	7	4
		0·200	135	19	192	45	13	6
Baisakhi 1977-78	*Palas*	0·125	51	2	—	—	—	—
		0·250	98	8	—	—	—	—
		0·500	122	12	—	—	—	—
		1·000	151	17	—	—	—	—
Baisakhi 1976-77	*Palas*	0·125	—	—	—	—	159	76
		0·250	—	—	—	—	239	105
		0·500	—	—	—	—	274	152
		1·000	—	—	—	—	369	167
Aghani 1976-77	*Kusum*	0·250	—	—	—	—	8	2
		0·500	—	—	—	—	12	7
		1·000	—	—	—	—	22	11
		2·000	—	—	—	—	42	14
	Bhalia	0·025	—	—	—	—	3	1
		0·050	—	—	—	—	12	7
		0·100	—	—	—	—	25	14
		0·200	—	—	—	—	31	16

TABLE 11 — EFFECT OF SEX-RATIO AND HOLDING TIME ON THE MATING PERFORMANCE/PROGENY OF *P. sulci*

Adults released Male: female ratio	Holding time (hr)	Adults emerged		
		Male (Av. No.)	Female (Av. No.)	Male: Female ratio
1:1	24	5·66	0	5·66:0
1:2	24	6·66	0	6·66:0
1:3	24	2·66	3·33	1:1·25
1:1	48	4·0	0	4:0
1:2	48	5·33	0	5·33:0
1:3	48	1·33	2·66	1:2
1:1	72	6·00	0	6:0
1:2	72	4·0	0	4:0
1:3	72	2·0	2·66	1:1·33
1:1	24	7·0	0	7:0
2:1	24	3·33	8·0	1:2·4
3:1	24	1·33	2·0	1:1·5
1:1	48	5·0	0	5:0
2:1	48	4·66	7·33	1:1·57
3:1	48	4·0	4·66	1:1·16
1:1	72	8·0	0	8:0
2:1	72	3·0	9·0	1:3
3:1	72	2·33	5·33	1:2·88

cide®) does not seem to affect the survival of the lac insect, development period of male and female insects, proportion of apterous and winged males, cell weight of mature females, fecundity and resin dye level.

(B. P. Mehra and B. N. Sah)

1.3.5 Studies taken up at Regional Field Research Station, Dharamjaigarh

The station at Dharamjaigarh continued to function during the year under report. The progress made in various items of investigation is reported here.

(a) *Evolution of a suitable technique for culturing lac on kusum under local conditions*

The technical programme has been detailed earlier (A.R.: 1973).

The data are presented in Table 13. It was observed that treatment C (involving the use of one and a half-year-old shoots) was relatively better than the other treatments, in both the cycles, although the crops were poor in all cases.

(b) *Investigation on indigenous plant species for use as alternative hosts to supplement kusmi lac production in the region*

One *dumar* or *gular* and one *jhera* trees were inoculated for *jethwi* 1977 and also for *aghani* 1977-78 which did not yield any crop.

TABLE 12 — EFFECT OF INSECTICIDAL CONTROL OF PREDATORS ON THE VITAL AND ECONOMIC ATTRIBUTES OF THE LAC INSECT

Crop season	Treatment	Effect on lac insects									
		Average % survival after		Average rearing period (days)		Average per cent males.			Average weight of mature female cell (mg)	Average fecundity (No. of larvae per female)	Average resin dye-level (optical density/ mg resin)
		1st spray (combination/ endosulfan spray)	II spray (combination spray)	Males	Females	Alate	Apterous	Total			
Jethwi 1977	Insecticide spray	61·02	*	66·11	163·88	1·42	20·47	21·89	16·02	521·02	0·0116
	Water spray	50·00	*	66·17	163·58	1·68	23·03	24·71	14·08	501·28	0·0102
Aghani 1977-78	Insecticide spray	54·3	65·00	62·20	208·38	0·48	26·92	27·40	16·05	288·97	0·0110
	Water spray	73·1	55·00	62·10	205·19	0·65	21·05	21·70	14·60	140·81	0·0101
Katki 1977	Insecticide spray	59·50	*	56·00	N.A.	2·34	22·30	24·64	N.A.	N.A.	N.A.
	Water spray	66·84	*	56·02	N.A.	0·37	32·72	33·09	N.A.	N.A.	N.A.

N.A.: Data not available since insects died during the post-mating period.
*Not applicable since second spraying is not recommended.

(c) *Introduction of lac-host plants not occurring naturally in the region*

(i) *Bhalia* (*Moghania macrophylla*)

The technical programme has already been detailed earlier (A.R.: 1974-76).

From the data collected for *jethwi* 1977 crop raised on *bhalia* it is seen that no broodlac was obtained from any treatment and scraped lac yield obtained from all the treatments was also poor.

No inoculation was done for *aghani* 1977-78 crop due to very poor condition of *bhalia* bushes.

(ii) *Galwang* (*Albizzia lucida*)

The plants were growing well.

(d) *Survey of the inimical and beneficial insects associated with kusmi lac in the region*

Emergence from *aghani* 1976-77 crop included the predators *Holcocera pulverea* and *Eublemma amabilis* and the beneficial parasites *Apanteles fakhrulhajiae* and *Apanteles techardiae*, and from *jethwi* 1977 crop the inimical parasites *Tetrastichus purpureus* and *Erencyrtus dewitzi*.

TABLE 13 — CROP PERFORMANCE UNDER THE DIFFERENT CULTIVATION PRACTICES TRIED FOR *kusum* AT DHARAMJAIGARH, M.P.

Crop	Treatment	Brood used (kg)		Yield (kg)		Crop ratio*
		Lac stick	Stick lac	Lac stick	Stick lac	
		JANUARY-JANUARY CYCLE				
Jethwi 1977-*cum*-*Aghani* 1977-78	A	16·8	6·6	15·000	2·40	1:0·36
Jethwi 1977-*cum*-*Aghani* 1977-78	B	24·6	5·9	4·600	0·51	1:0·08
Jethwi 1977+*Aghani* 1977-78	C	60·0	18·3	53·300	17·61	1:0·96
Jethwi 1977+*Aghani* 1977-78-(partial harvest)	D	13·0	4·5	10·400	3·10	1:0·68
		JULY-JULY CYCLE				
Aghani 1976-77-*cum*-*Jethwi* 1977	A	45·0	15·8	39·200	7·90	1:0·49
do	B	36·8	16·1	28·900	4·73	1:0·29
Aghani 1976-77+*Jethwi* 1977	C	99·1	36·2	110·400	24·25	1:0·79
Aghani 1976-77+*Jethwi* 1977 (partial harvest)	D	17·0	6·5	20·200	4·90	1:0·75

*Crop ratio refers to the ratio of yield to brood lac used in terms of stick lac.

(B. P. Mehra and J. M. Dasgupta)

1.4 Integrated Control of the Enemies of Lac Insects

1.4.1 Field trials of envisaged integrated control schedules against the lac predators

(i) *Aghani* 1976-77 crop on *Moghania macrophylla* at Amjharia

There were six treatments in this study, namely, EC, CE, CC, BC, EE and N (control, sprayed with water only), with five replications.

Treatment symbols stand as under:

E = 0·05% endosulfan (Thiodan®).

B = 0·05% *Bacillus thuringiensis* (*B.th.*) prepared from Thuricide®.

C = Combination spray of 0·05% endosulfan and 0·05% *B.th.* in equal proportion.

Aghani 1976-77 crop was inoculated on 150 bushes on 3 July 1976. The first spray application was made on 6 August 1976 soon after *phunki* removal, and the second on 27 August 1976 about three weeks after the first spray. The crop was harvested at maturity on 21 January 1977.

Data on suppression of predatory fauna was obtained by caging samples.

The results on yield and suppression of predatory fauna are presented in Table 14. It may be seen that the schedule CC gave slightly better results with regard to yield of broodlac and the schedules EE and CE with regard to both brood lac and stick lac as compared to the control. However, no definite relationship of the increase in yield with the suppression of predatory fauna is seen from the data.

(ii) *Baisakhi* 1976-77-*cum-katki* 1977 crop on *palas* at Lota Farm.

Due to non-availability of Thuricide®, the programme was slightly modified by using three concentrations, namely, 0·05, 0·075 and 0·1% of endosulfan and a newly introduced insecticide, namely, cryolite at 0·1%. In the earlier studies, cryolite was found harmless to the lac insect but fairly toxic to the predators with added advantage that it was least disruptive to the environment. These treatments were applied either once in February 1977 or twice during the months of February and May 1977 and once during August 1977 as per details presented in Table 15.

There were in all 9 treatments with 5 replications and 2 trees per replication, making a total of 90 trees under the trial. Due to fear of theft, twigs bearing heavy settlement of lac insects were harvested from all the treatments during April as *ari* and the yield obtained was accounted.

It may be seen from the data presented in Table 15 that comparatively better results with regard to yield of stick lac were obtained from the trees treated with a total of 3 sprays as compared to 2 sprays of endosulfan at its three concentrations tried and also in comparison to the control. Cryolite 0·1% at the level of 2 or 3 sprays did not result in increase in crop yield. In this study also, no definite relationship of the increase in yield with the suppression of predatory fauna is seen from the data.

(C. P. Malhotra, R. C. Mishra and T. P. S. Teotia, Co-operator)

TABLE 14 — EFFECT OF VARIOUS CONTROL SCHEDULES ON THE LAC CROP YIELDS AND I

Treatment code	Brood lac used per bush (g)		Average lac yield/bush (g)					
			Lac stick			Stick lac		
	Lac stick	Stick lac	Brood lac	Rejected lac	Total	Brood lac	Rejected lac	Total
N	80·0	31·2	66·0	100·0	166·0	16·0	7·8	23·8
EC	83·3	30·3	72·3	80·0	152·3	17·0	6·0	23·0
CE	84·2	32·0	90·0	63·0	153·0	20·0	5·0	25·0
CC	87·5	30·8	111·0	38·0	149·0	16·2	2·9	19·1
BC	80·9	22·4	32·0	95·0	127·0	9·3	6·3	15·6
EE	90·0	29·3	80·0	56·0	136·0	19·0	4·0	23·0

TABLE 15 — EFFECT OF VARIOUS CONTROL SCHEDULES ON THE LAC CROP YIELDS AND PRED

Treatment code	Insecticides	Concentration %	Total No. of sprays	Brood lac used/tree (g)		Average yield/tree (g)					Brood used to yield ratio	
				Lac stick	Stick lac	April (ari)		Oct./Nov. (mature)		Total stick lac	Brood lac stick	Stick lac
						Lac stick	Stick lac	Brood lac	Stick lac			
A	Endosulfan	0·05	2	300	63·12	399·75	78·12	275·00	48·05	126·17	1 : 0·92	1 : 1·99
B	do	0·05	3	300	57·00	421·42	89·28	171·42	94·28	183·56	1 : 0·57	1 : 3·22
C	do	0·075	2	300	58·12	368·75	74·37	93·75	32·50	106·87	1 : 0·31	1 : 1·83
D	do	0·075	3	300	52·50	350·00	71·80	256·00	86·80	158·60	1 : 0·85	1 : 3·02
E	do	0·1	2	300	55·00	343·70	62·20	100·00	35·62	97·82	1 : 0·33	1 : 1·78
F	do	0·1	3	300	56·30	418·70	74·00	225·00	83·75	157·75	1 : 0·75	1 : 2·80
G	Cryolite	0·1	2	300	61·10	118·70	23·00	503·00	12·00	35·00	1 : 1·68	1 : 0·57
H	do	0·1	3	300	52·75	200·00	35·00	50·00	68·30	103·30	1 : 0·17	1 : 1·95
I	Control	—	—	300	63·75	353·10	91·80	375·00	68·30	160·10	1 : 1·25	1 : 2·51

REDATOR POPULATION IN *aghani* 1976-77 CROP ON *Moghania macrophylla* AT AMJHARIA

Brood used to yield ratio		Average No. of predators per 100 g stick lac			Per cent suppression of predators		
Brood lac stick	Stick lac	*Eublemma amabilis*	*Holcocera pulverea*	Total	*Eublemma amabilis*	*Holcocera pulverea*	Total
1:0·82	1:0·76	7·1	49·6	56·7	—	—	—
1:0·86	1:0·75	2·3	33·8	36·1	67·60	31·85	36·33
1:1·06	1:0·78	3·9	35·2	39·1	45·07	29·03	31·04
1:1·26	1:0·62	1·5	44·7	46·2	78·87	9·88	18·52
1:0·39	1:0·69	1·8	28·6	30·4	74·65	42·34	46·38
1:0·88	1:0·78	1·9	34·5	36·4	73·23	30·44	35·80

TOR POPULATION IN THE *baisakhi* 1976-77-*cum-katki* 1977 CROP ON *palas* AT LOTA FARM

Average No. of predators per metre lac stick in April 1977			Average No. of predators per 100 g stick lac in October 1977			Percentage suppression of predators					
						April 1977			October 1977		
E.a.	*H.p.*	Total	*E.a.*	*H.p.*	Total	*E.a.*	*H.p.*	Total	*E.a.*	*H.p.*	Total
4·12	2·53	6·65	15·29	8·23	23·52	7·41	72·82	66·63	22·58	46·67	33·14
2·17	2·64	4·81	9·47	8·42	17·89	51·23	71·64	65·04	52·05	45·43	49·15
4·90	3·39	8·29	21·11	7·70	28·81	0·00	63·58	39·75	0·00	50·10	18·11
2·00	2·00	4·00	18·69	13·40	32·09	55·05	78·51	70·93	5·37	13·16	8·78
1·86	3·35	5·21	14·88	14·28	29·16	58·20	64·02	62·14	24·66	7·45	17·11
0·37	0·74	1·11	12·81	10·31	23·12	91·68	92·05	91·93	35·14	33·18	34·28
7·56	9·18	16·74	13·86	15·45	29·31	0·00	1·40	0·00	29·82	0·00	16·68
2·70	2·70	5·40	11·42	12·85	24·27	39·32	71·00	60·75	42·18	16·72	31·01
4·45	9·31	13·76	19·76	15·43	35·18	—	—	—	—	—	—

1.4.2 Evolving cultural control for the enemies of lac insect

(ii) *Effect of varying the time of crop inoculation*

The measure aims at exploring the possibilities of controlling the lac predator, *E. amabilis*, by varying the time of lac inoculation and thereby causing asynchronization between the pest cycle *vis-a-vis* the lac insect.

Attempts made to procure the broodlac maturing at distinctly different times from Assam, Punjab, Delhi and Jodhpur having failed, broodlac from within Bihar was, therefore, collected from Namkum, Chandwa and at three intervals from Kundri. The trial was conducted at Kundri where inoculations were made with Chandwa brood on 11 October 1976 (E), Namkum brood on 22 October 1976 (N), and Kundri brood on 27 October 1976 (K), 1 November 1976 (KI) and 9 November 1976 (KL) on an unit of 5 trees each, replicated five times. There were thus a total of 125 trees under the trial.

Baisakhi 1976-77-*cum-katki* 1977 crop was harvested during the period under report (Table 16). Highest sticklac yield was recorded from inoculation made on 1 November 1976 with Kundri brood (KI) and the lowest from inoculation made on 22 October 1976 with Namkum brood (N). The results further reveal that compared with treatment N (inoculation on 22 October 1976) which recorded maximum incidence of predators both in April and October, a reduction in predator population occurred both when inoculation was done earlier or later than this date. This study, however, requires further confirmation.

(C. P. Malhotra and R. C. Mishra)

1.4.7 Estimation of losses caused by the enemy insects of lac

The project was initiated during the year 1976 at Namkum plantation. Two methods of protection of lac crops from the enemy insects were tried, namely, (i) *mechanical*, where improvised 60-mesh synthetic netting cages were tied on the lac bearing branches, and (ii) *Chemical*, where spraying of 0·05% each of *Bacillus thuringiensis* and Thiodan®, mixed in equal proportion, was given at intervals commencing from the date of *phunki* removal and continued upto the time of maturity of lac crops.

For the above, bushes/trees were inoculated normally and on maturity of crops 4-6 twigs bearing uniform and equitable settlement of lac larvae were selected at random from protected and unprotected (control) bushes/trees to record the effect of mechanical and/or chemical protection. Comparisons were drawn on the basis of yield of lac obtained from the protected twigs with those of unprotected (control) ones. Enemy insects were also recorded by caging the samples brought in the laboratory at crop maturity from either treatment.

Crop-wise details are given below and the data are presented in Table 17.

(i) *Aghani* 1976-77 crop on *kusum*

Lac crop was raised on 40 trees and 40 bushes, of which 20 each were provided with chemical umbrella. Results revealed 49·6% loss in yield on trees and 50·1% on bushes due to enemy insects.

(ii) *Baisakhi* 1976-77 crop on *palas*

Mechanical measure adopted to protect the *baisakhi* 1976-77 crop on *palas* revealed 48·9 per cent loss in yield due to enemy insects.

TABLE 16 — EFFECT OF VARYING THE DATES OF INOCULATION ON THE LAC CROP YIELD AND THE INCIDENCE OF LAC PREDATORS IN THE *baisakhi* 1976-77-*cum-katki* 1977 CROP ON *palas* AT KUNDRI FARM

Treatment code	Brood lac used/tree (g)		Average lac yield/tree (g)						Brood used to yield ratios	
			Lac stick			Stick lac				
	Lac stick	Stick lac	Brood lac	Rejected lac	Total	Brood lac	Rejected lac	Total	Brood lac stick	Stick lac
E	1250	0·215	9·380	6·700	16·080	1·691	0·900	2·591	1 : 7·50	1 : 12·05
N	1250	0·250	9·020	7·460	16·480	1·600	0·860	2·460	1 : 7·22	1 : 9·84
K	1250	0·250	10·100	8·360	18·460	1·841	1·180	3·021	1 : 8·08	1 : 12·08
KI	1250	0·245	12·840	10·560	23·400	2·317	0·760	3·077	1 : 10·27	1 : 12·56
KL	1250	0·250	11·080	4·900	15·980	2·045	0·603	2·648	1 : 8·86	1 : 10·59

Average No. of predators/metre lac stick in April 1977			Average No. of predators/100 g stick lac in October 1977		
Eublemma amabilis	*Holcocera pulverea*	Total	*Eublemma amabilis*	*Holcocera pulverea*	Total
30·30	22·30	52·60	5·80	3·98	9·78
47·90	32·70	80·60	13·19	7·98	21·17
21·00	19·20	40·20	9·13	2·89	12·02
22·00	25·50	47·50	9·00	7·50	16·50
29·30	21·30	50·60	9·24	3·65	12·89

TABLE 17 — ESTIMATION OF LOSSES CAUSED BY THE ENEMY INSECTS OF THE LAC INSECT DURING VARIOUS CROP SEASONS (1976-77)

Crop	Host plant	Treat-ment	Total number of samples, trees, bushes	Total length of samples (cm)	Yield/100 cm sample or tree, or bush (g)		Per-centage avoidable loss in yield of stick lac	Emergence of enemy insects from samples calculated per 100 g			Percentage reduction of enemy insects		
					Lac stick	Stick lac		*E.a.*	*H.p.*	Harmful parasites	*E.a.*	*H.p.*	Harmful parasites
Baisakhi 1976-77	*Palas* (bushes)	A	101	4040	220	56	48·9	Not recorded					
		C	101	4040	152	28							
Aghani 1976-77	*Kusum* (bushes)	B	20	—	129	51	50·1	Not recorded					
		C	20	—	51	25							
	Kusum (trees)	B	20	—	1212	414	49·6	5·59	2·06	0·37	78·7	83·1	96·1
		C	20	—	432	209		26·32	12·25	9·38			
Jethwi 1977	*Kusum* (trees)	B	10	—	2634	503·2	21·5	4·46	1·61	Nil	64·7	33·1	—
		C	10	—	2270	400·7		12·59	2·41	Nil			
Katki 1977	*Bhalia* (bushes)	A	45	1900	41	5	56·80	Nil	Nil	Nil	100	100	100
		B	45	1900	25	4	44·57	4·2	3·1	3·9	90·5	75·7	27·7
		C	45	1900	28	2		44·6	12·8	5·4			

A — Mechanical protection, B — Chemical protection, C — Control, *E.a.*— *Eublemma amabilis*, *H.p.*— *Holcocera pulverea*, Total sprays in *aghani* = 15, Total sprays in *katki* = 9.

(iii) *Jethwi* 1977 crop on *kusum*

This crop was raised on 20 *kusum* trees, of which 10 were kept under control and 10 were provided with chemical umbrella. Percentage loss in yield was assessed as 21·5 and percentage reduction of *E. amabilis* and *H. pulverea* was to the extent of 64·7 and 33·1 respectively.

(iv) *Katki* 1977 crop on *Moghania macrophylla*

Lac crop was raised on 45 bushes and all the three treatments, namely, chemical, mechanical and control were tried, with five bushes under each, replicated thrice.

Percentage loss in yield based on mechanically protected crop came to 56·8, whereas that based on chemically protected crop came to 44·5.

Mechanical protection afforded complete protection of the crop from the enemy insects, whereas chemical protection afforded reduction of *E. amabilis*, *H. pulverea* and harmful parasites to the extent of 90·5, 75·7 and 27·7 per cent respectively.

(C. P. Malhotra and S. G. Choudhary)

1.5 Breeding and Genetical Studies on Lac Insects

1.5.2 Study of crosses of *rangeeni* and *kusmi* strains of lac insects

The lines derived from crosses of the *rangeeni* and *kusmi* strains of lac insects were maintained, a few of which were found to include insects which followed *rangeeni* life-cycle but produced the *kusmi* type, i.e. lighter coloured resin, suggesting possibility of boosting production of the desired lighter coloured resin.

The lines, however, remain to be evaluated for the other qualities of lac insects.

(N. S. Chauhan and Jawahirlal)

1.5.3 Mutation studies in lac insects

The second and third generation progenies derived from the *jethwi* 1976 males, X-irradiated at 2000 and 4000 r, were maintained. No variant lac insect, however, has been recorded so far.

The *baisakhi* 1976-77 males were X-irradiated soon after their emergence from the lac cells using doses ranging between 1000 and 40,000 r. The survivors were each mated to a virgin female. The progenies are awaited.

Both the male and female lac insects were X-irradiated at 2000 and 4000 r in the rainy season generation. The progenies are awaited.

It has been observed that the *rangeeni* insects are perhaps more tolerant to X-irradiation than the *kusmi* insects.

(N. S. Chauhan and S. N. Mukherjee)

1.5.5 Cytological studies in lac insects

Efforts were made to study oogenesis in lac insects along with its cytology and cytochemistry.

Female lac insects of different ages from second instar onward were collected from *baisakhi* 1976-77 crop and fixed separately in Flemming's solution

without acetic acid (75 cc of 1% chromic acid+20 cc of 2% osmium tetraoxide). The insects were subjected separately after fixation to chroming and post-osmification with saturated solution of potassium dichromate and 2 per cent osmic acid, respectively. The material was then dehydrated and embedded in paraffin blocks for section cutting for the study of germinal tissues.

Studies were also carried out to determine the role of nurse cells, mitochondria and Golgi bodies in yolk formation during oogenesis of lac insects. Thus, the fresh eggs of lac insects were treated with 2 per cent osmic acid for a short period for studying the morphology and chemical nature of Golgi bodies in particular and other cytoplasmic inclusions in general. It was observed that when the eggs of lac insect were kept in 2 per cent osmic acid for 10 min. each yolk element appeared as a vacuole with a black chromophilic rim and central chromophobic substance. But when the period of osmification was extended to more than half an hour the yolk vacuole appeared solid and black. This blackening of vacuoles indicates the presence of fatty yolk. The experiment is to be repeated for confirmation.

(T. P. S. Teotia, S. K. Jaipuriar and N. S. Chauhan)

1.5.8 Collection, maintenance and evaluation of genetic stocks of lac insects

The following stocks of the *rangeeni* and *kusmi* strains of lac insects were maintained during the period under report.

Kusmi: (1) Local (Ranchi), (2) Orissa, (3) Madhya Pradesh and (4) Tamil Nadu.

Rangeeni: (1) Local (Ranchi), (2) Madhya Pradesh, (3) Delhi and (4) Punjab.

Five cultures of each stock were maintained, each on a potted *bhalia* (*Moghania macrophylla*) plant for a comparative study of the economic qualities of these insects.

(N. S. Chauhan and Jawahirlal)

(c) RESEARCHES CONTEMPLATED

Nil

(d) OPERATIONAL RESEARCH PROJECT

The demonstrations of improved method of lac cultivation conducted last year for *baisakhi* 1976-77 *cum katki* 1977 crop for broodlac on *palas* and for *baisakhi* 1976-77 *ari* (immature) crop for sticklac on *ber*/*palas* in the two villages, namely, Barguttu and Saheda were continued and the sale of sticklac was arranged at the support price of Rs 3 per kg through BISCOLAMF. Having been tempted with the remunerative sale of sticklac, the lac growers unfortunately harvested their broodlac crop also along with *ari* sticklac crop and thereby vitiated the programme of demonstration. Available data for *ari* harvest have, however, recorded the yield of 6·46 kg and 2·38 kg sticklac per *ber* tree under improved and villagers' method of lac cultivation respectively. A few *palas* trees which were not harvested as *ari* recorded the yield of 1·9 kg broodlac per tree during October-November 1977 under improved method whereas no such trees could be found under villagers' method for comparison. These data have indicated that yield of sticklac per tree can be increased to a tune of 2·7 times by the improved method of lac cultivation.

Low price of lac and problem of theft were experienced as the major constraints in this avocation.

These demonstrations were conducted during next season in all the four villages for *baisakhi* 1977-78 *cum-katki* '78 crop and for *baisakhi* 1977-78 *ari* (immature) crop on 874 trees of *palas* and *ber* involving 23 cultivators with broodlac supplied, free of cost, as subsidy. The *phunki* lac sticks have been removed and the crop condition was satisfactory up to this period. It was noted during *phunki* removal that synthetic netting broodlac containers are damaged by rats and hence need improvement.

(D. C. Srivastava)

B. AGRONOMY AND PLANT GENETICS DIVISION

(a) RESEARCHES COMPLETED

Nil

(b) RESEARCHES ON HAND

2.1 Lac Cultivation and Host Plant

2.1.1 Lac cultivation on *arhar* (*Cajanus cajan*)

Expt. 1 — *Screening of arhar varieties/cultivars for lac cultivation*

Forty varieties including some promising cultivars obtained from ICRISAT, Hyderabad, were raised from seeds in July 1976. One set was inoculated in the month of October 1976 with *rangeeni* strain of lac insect while another set of uninoculated plants was kept as control to compare the grain yield on these plants with those of inoculated ones.

There was no distinguishable difference in grain yield from both the sets. Table 18 shows the comparative yield of grain and lac from different varieties/ cultivars. Assam cultivar has been found to be the best in respect of lac yield while ICRISAT No. 4725, 3682 and 6986 for grain yield.

(Sohan Lal and B. P. Singh)

2.1.2 Lac cultivation on *bhalia* (*Moghania macrophylla*)

Expt. 1 — *Effect of spacing, systems of planting and fertilizers on plant growth and lac yield*

The experiment was laid out in split-plot design to study the effects of spacing, planting systems and fertilizers on growth of plants and yield of lac. *Bhalia* plants inoculated in July '76 were harvested towards the end of January 1977. The crop yield data (Table 19) compared between the treatments revealed that the equitriangular system of planting (Q) with 1·25 m × 1·25 m spacing (S_2) followed by the application of phosphatic fertilizers gave better results with respect to broodlac yield whereas regular planting (R) system with 1 m × 1 m spacing (S_1) and the combination of nitrogenous and phosphatic fertilizers recorded higher sticklac yield per hectare.

(Sohan Lal and B. P. Singh)

TABLE 18 — YIELD OF GRAIN FROM BOTH UNINOCULATED AND INOCULATED SETS AND LAC YIELD FROM INOCULATED SETS

Sl No.	Varieties/cultivars	Yield of grain/plant (g)		Yield of sticklac/ plant (g)
		Uninoculated	Inoculated	
1	ICRISAT No. 7035	46	46	30
2	ICRISAT No. 7170	50	49	26
3	ICRISAT No. 7970	49	49	21
4	ICRISAT No. 3682	58	56	19
5	ICRISAT No. 38	53	54	20
6	ICRISAT No. 7409	46	46	16
7	ICRISAT No. 1	55	53	18
8	ICRISAT No. 6986	57	55	17
9	ICRISAT No. 1156	46	46	25
10	ICRISAT No. 6494	51	53	24
11	ICRISAT No. 4725	57	57	10
12	ICRISAT No. 6393	52	52	23
13	ICRISAT No. 71782	51	48	28
14	ICRISAT No. 4711	53	52	23
15	ICRISAT No. 3782	51	52	16
16	ICRISAT No. 1180	48	48	12
17	ICRISAT No. 6989	43	44	27
18	ICRISAT No. 6397	49	50	17
19	PLA 520	30	29	15
20	PLA 232	49	48	20
21	PLA 316	44	44	15
22	PLA 538	49	48	13
23	AS-3	41	44	15
24	Sarda	54	54	13
25	PLA 396	41	20	19
26	PLA 542	38	36	16
27	S-5	28	20	20
28	PLA 230	34	34	14
29	Dholi 1258	39	38	16
30	PLA 399	37	37	19
31	Perennial Assam	50	50	40
32	AS 29	34	30	25
33	PLA 643	24	25	24
34	RB 183	50	50	16
35	BR 65	27	26	17
36	Local Collection Ranchi	41	40	14
37	Mukta	38	36	24
38	R-17	31	30	12
39	PLA 679	34	32	16
40	T-21	48	47	24

TABLE 19 — BROODLAC AND STICK LAC YIELD OF *Bhalia* (*Moghania macrophylla*) UNDER DIFFERENT TREATMENTS

Treatment	Broodlac yield/ha (kg)					Sticklac yield/ha (kg)				
	S_1		S_2		Mean	S_1		S_2		Mean
	R	Q	R	Q		R	Q	R	Q	
N	113	141	125	131	127·5	78	97	99	86	90·0
P	156	127	113	213	152·2	83	116	95	113	101·7
NP	194	153	150	123	155·0	127	102	106	122	114·2
C (Control)	75	99	94	109	94·2	91	80	97	104	93·0
Mean	134·5	130·0	120·5	144·0	—	94·7	98·7	99·2	106·2	—
Mean	S_1 132·2		S_2 132·2			S_1 96·7		S_2 102·7		

2.3 Aboricultural Studies

2.3.1 Introduction of rain tree for lac cultivation

Expt. 2 — *Growing of rain tree into bushes*

The experiment is being continued since 1973 with split-plot design under three different factors, namely, spacing, coppicing height and seasons of coppicing.

The plant coppiced at a height of 15 cm (H_1) showed better growth response to other treatments. No significant difference was observed between March (M_1) and May (M_2) coppicing though both were found to be superior to July (M_3) coppicing (Table 20). Treatment differences were not significant with respect to spacing. The maximum shoot length per plant (308·6 cm) was obtained for treatment combination $S_3H_1M_2$, followed by $S_3H_1M_1$ (307·6 cm) and $S_1H_1M_1$ (300·1 cm).

TABLE 20 — AVERAGE TOTAL SHOOT LENGTH PER PLANT (CM)

Treatment	Spacings								
	S_1 (1·8 m×1·8 m)			S_2 (1·8 m×2·7 m)			S_3 (1·8 m×3·6 m)		
Coppicing height/ month of coppicing	H_1 15 cm	H_2 30 cm	H_3 45 cm	H_1 15 cm	H_2 30 cm	H_3 45 cm	H_1 15 cm	H_2 30 cm	H_3 45 cm
M_1 (March)	300·1	272·6	142·7	185·4	280·2	226·3	307·6	289·1	289·5
M_2 (May)	198·8	171·5	167·3	147·1	234·1	247·9	308·6	243·8	248·8
M_3 (July)	157·6	96·3	175·5	153·3	122·6	159·5	200·8	175·5	191·7

C.D. at 5% −55·2; C.D. at 1% −73·5 for month of coppicing.

(B. K. Purkayastha and Moti Ram)

2.3.2 Role of plant growth regulators on growth of bushy lac-host plants

Expt. 1 — *Influence of pre-treatment of Moghania seeds with growth regulators in relation to lac yield*

As reported earlier, the same four concentrations of growth regulators, namely, NAA and GA (10, 20, 40 and 80 ppm) were tried this year and distilled water was used in the control.

The pre-treatment of seeds with NAA showed increased shoot length whereas poor growth was observed with GA as compared to the control. The best result (Table 21) was obtained in plants raised from seeds treated with NAA at 80 ppm and it was in conformity with the previous findings.

TABLE 21 — EFFECT OF PRE-TREATMENT OF *Moghania* SEEDS WITH GROWTH REGULATORS ON SHOOT GROWTH AND YIELD OF LAC

Treatment	Total shoot length/plant (cm)	Per plant yield of lac (g)
GA 10 ppm	935	45
GA 20 ppm	967	47
GA 40 ppm	1062	53
GA 80 ppm	1153	55
NAA 10 ppm	1076	65
NAA 20 ppm	1126	75
NAA 40 ppm	1196	89
NAA 80 ppm	1354	107
Control	1055	53
C.D. at 5%	86·67	—

Aghani (Winter) 1976-77 lac crop was grown on these bushes. The analysis of crop data revealed that the treatment NAA at 80 ppm was superior to all other treatments with respect to yield of lac. The increase in yield over the control has been recorded as 102·2% which may be due to larger number of available shoot length for lac inoculation in comparison to the control.

Expt. 2 — *Effect of GA on the growth of plants*

The host-plants kept under trial were *Moghania macrophylla* and *Albizzia lucida*.

Moghania macrophylla (1975 set).

Moghania bushes treated with GA were inoculated with lac to raise the *aghani* 1976-77 crop. The bushes given foliar spray of GA at 40 ppm have shown the best results in respect of yield of lac which may be due to greater shoot length (Table 22). There has also been significant difference between the treatments.

Albizzia lucida

The plants coppiced in March 1976 were inoculated with lac in January 1977 for growing the *jethwi* 1977 crop. The crop yield data when compared between the treatments showed that the plants treated with GA at 40 ppm had the best

TABLE 22 — EFFECT OF FOLIAR SPRAY OF GA ON SHOOT GROWTH AND YIELD OF LAC

Host Treatment	*Moghania macrophylla*		*Albizzia lucida*	
	Total shoot length/plant (cm)	Per plant yield of lac (g)	Total shoot length/plant (cm)	Per plant yield of lac (g)
Control	923	76	357	72
GA 20 ppm	1008	84	460	86
GA 40 ppm	1183	109	681	143
GA 80 ppm	1054	90	497	94
C.D. at 5%	NS	9·32	135·59	19·19

effect which was in conformity with the results of the previous season. The increase in yield over the control was 98·6 per cent and the treatment differences were also significant.

(B. K. Purkayastha and Moti Ram)

2.3.3 Vegetative propagation of *Kusum* (*Schleichera oleosa*)

The experiment was initiated in March 1977 to investigate the possibilities of multiplying *kusum* trees by adopting the following methods: (a) Air-layering, (b) Stem cutting, (c) Cincturing. However, none of the methods has been successful so far. The study is being continued.

(B. K. Purkayastha and Moti Ram)

2.4 Genetics and Breeding Studies

2.4.1 Cytotaxonomic and mutational studies of lac-host plants

With a view to inducing mutations for improved lac productivity, *bhalia* seeds irradiated with X-rays at various doses ranging from 10 to 60 kr were sown in nursery beds along with the untreated seeds. The germination percentage decreased with the increase in doses of irradiation (Table 23).

TABLE 23 — EFFECT OF X-RAYS ON GERMINATION OF *bhalia* SEEDS IN M_1 GENERATION

Treatment	Seeds sown No.	Seeds germinated No.	Germination (%)
Control	300	103	31·00
10 kr	300	92	30·66
20 kr	300	56	18·66
30 kr	300	28	9·33
40 kr	300	24	8·00
50 kr	300	6	2·00
60 kr	300	6	2·00

Bhalia plants raised earlier from gamma-irradiated seeds were coppiced during Jan.-Feb. 1977, and inoculated to raise *aghani* 1977-78 crop. The observations were recorded on number of primary branches and total shoot length at the time of inoculation (Table 24). Spraying of Thiodan® (0·05%) and *Bacillus thuringiensis* (0·05%) was carried out to check the attack of predators and parasites. Hand picking was also carried out to minimize the incidence. It is not possible to draw any inference at this stage from the results obtained so far.

TABLE 24 — EFFECT OF GAMMA RAYS ON NUMBER OF PRIMARY BRANCHES AND TOTAL SHOOT LENGTH OF *bhalia* PLANTS IN M_1 GENERATION AT THE TIME OF LAC INOCULATION

Treatment	No. of primary branches per plant	Total shoot length/per plant (cm)
Control	3·04	225·18
10 kr	2·43	217·04
20 kr	3·00	204·82
30 kr	2·94	241·89
40 kr	2·75	207·33
50 kr	4·00	310·93

2.4.2 Possibility of inter-specific crossing in *Moghania* species

To facilitate inter-specific crosses between two *Moghania* species, the floral biology of these two plants was studied on the following aspects:

(i) *Floral bud initiation and its development*

Initiation of bud was observed during August/September in *M. macrophylla* and October/November in *M. chappar*. To study the development of flower, the newly emerged flower buds of both the species were tagged for observations. Their length was measured at one-day interval. The period required from bud initiation to full bloom stage ranged between 24 to 26 days in *M. chappar* and 8 to 10 days in *M. macrophylla* (Table 25).

TABLE 25 — FLORAL BUD INITIATION AND DEVELOPMENT IN *Moghania* spp.

Stages of development	Size of bud (mm)	Time taken in days (Range)
	M. chappar	
1. Separation of sepals	4-6	10-15
2. Separation of standard	6-8	18-21
3. Separation of wings	8-10	20-25
4. Full bloom stage	10-12	24-26
	M. macrophylla	
1. Separation of sepals	7-10	3-5
2. Separation of standard	9-11	4-6
3. Separation of wings	10-13	7-9
4. Full bloom stage	12-14	8-10

(ii) *Pollen morphology*

Pollens of both the species were globular in wet condition and oblong with tapered end in dry condition. They were whitish and powdery at the time of dehiscence in both the species. Average diameter of pollens was noted as 40·96 and 35·88 μ in *M. chappar* and *M. macrophylla* respectively.

(iii) *Dehiscence of anthers*

It was observed that anthesis starts at 5.00 a.m. in *M. macrophylla.* The maximum percentage of anthesis was noted at 7.00 a.m. (Table 26).

TABLE 26 — PERCENTAGE OF DEHISCENCE OF ANTHERS AT DIFFERENT HOURS (*M. macrophylla*)

Date	5.00 A.M.	5.30 A.M.	6.00 A.M.	6.30 A.M.	7.00 A.M.
18 Sept. 1977	5·2	20·8	40·7	60·6	90·6
19 Sept. 1977	10·6	20·3	60·4	70·7	100·0
20 Sept. 1977	5·2	30·4	60·6	80·8	100·0
21 Sept. 1977	10·3	25·6	70·4	90·0	100·0

(iv) *Pollen germination test*

M. chappar — The pollen germination was maximum (61·15%) on sucrose solution (75%) + agar agar (1%) and the tube length measured maximum 159·04 μ in a medium comprising of sucrose solution (75%) + agar-agar (1%) + traces of Ca-complex (Table 27).

TABLE 27 — POLLEN GERMINATION TEST RESULTS OF *bara salpan* IN OPTIMAL MEDIA OF SUCROSE SOLUTION (75%)+AGAR-AGAR (1%), WITH AND WITHOUT Ca-COMPLEX

Sl No.	Germination (%)	Pollen tube length (μ)
	WITH Ca-COMPLEX	
1	57·14	136·80
2	42·85	157·80
3	54·54	136·70
4	40·00	210·40
5	46·15	157·80
Mean	47·37	159·04
	WITHOUT Ca-COMPLEX	
1	61·90	73·64
2	60·00	52·60
3	61·11	52·60
4	62·50	136·80
5	60·86	94·68
Mean	61·15	82·06

Since *bhalia* (*M. macrophylla*) flowers earlier than *bara salpan* (*M. chappar*), only the pollens of *bhalia* could be used as male parent. Hence the following studies were limited only to *bhalia* in the first stage.

M. macrophylla — The germination test of *bhalia* pollens collected at different intervals after dehiscence of anthers was carried out in optimal medium of sucrose solution (45%) + agar-agar (1%). It was observed that pollen germination started after 3 hr of anthesis and reached maximum after 4½ hr (Table 28).

TABLE 28 — GERMINATION PERCENTAGE OF *bhalia* POLLENS COLLECTED AT DIFFERENT INTERVALS OF ANTHESIS

Pollen collected after anthesis (hr)	Pollen viability (%)	Tube length (μ)
3	—	—
3½	35·8	125·00
4	48·4	110·00
4½	57·9	133·12
5	67·6	125·00
5½	24·3	122·88

(P. Kumar and S. C. Srivastava)

2.4.3 Selection for better performance of *Moghania macrophylla* as a lac host for *kusmi* strain of lac insects

In order to make selection in *bhalia* plants with regard to lac productivity, the above study was continued in both *jethwi* and *aghani* crops.

(i) *Jethwi*

Out of 40 high and 10 low lac-yielding plants of two extremes selected for further study, seeds which could be obtained only from 27 (high) and 9 (low) plants were sown in nursery beds. The numbers of seeds sown for individual selected plant were twentyfive. The germination percentage recorded was from zero to fifty. The seedlings were transplanted in progeny rows. The plants are growing well.

(ii) *Aghani*

Bhalia plants raised in July 1975 were coppiced during first week of February 1977. All the plants were inoculated during June-July to raise *aghani* 1977-78 crop. The inflorescences were bagged during September for selfing and the seeds were collected from individual plants during December for next year's progeny trial.

(P. Kumar and S. C. Srivastava)

(c) RESEARCHES CONTEMPLATED

2.1.3 Integration of lac cultivation with general agriculture under dry farming conditions.

(d) INSTITUTE PLANTATION

General upkeep of the plantation was maintained as far as possible. Seedlings of various lac hosts were raised in nursery beds for filling up gaps and vacant plots and also for use in earthen pots for laboratory experiments. Hoeing and weeding were carried out to keep down the weeds.

(e) SCHEME ON THE CULTIVATION OF *KUSMI* LAC ON *BHALIA* AND *GALWANG* IN MIXED PLANTATION AT CHANDWA

Harvesting of *aghani* 1976-77 lac crop from *bhalia* bushes (8000) was carried out in February 1977. The crop was badly damaged due to severe infestation of predators as reported earlier (A.R.: 1974-76). The yield of scraped lac was 100 kg and broodlac was 120 kg.

During the period under report *bhalia* bushes (9000) were inoculated for raising *aghani* 1977-78 crop. Though the initial settlement was quite good, the crop was severely affected due to the attack of predators in August-September 1977 season, in spite of protective measures taken by insecticidal sprays.

The growth of *galwang* plants of 1976 set was far from satisfactory in comparison with the growth of the plants raised at the Institute Plantation, because the edaphic and climatic factors at Chandwa do not appear to be suitable for their growth.

(B. K. Purkayastha)

C. CHEMISTRY DIVISION

(a) RESEARCHES COMPLETED

3.2.3 Modification of hydrolysed lac and its utilization

Hydrolysed lac was modified by reacting it with epichlorohydrin under different conditions so as to introduce epoxy group in it which has excellent adhesive and chemical resistant properties.

The maximum epoxide value which could be obtained was 0·192 eq/100 g. For obtaining the product, hydrolysed lac (20 g) had to be reacted with epichlorohydrin (60 g) in presence of boron trifluoride in nitrogen atmosphere followed by dissolution in dioxane (300 ml) and refluxing in presence of sodium aluminate (15 g).

Curing of the product with isocyanate gave very hard films even at room temperature after 24 hr. The films were glossy and resistant to water, dilute acids and alkalies.

Modification of hydrolysed lac with epoxy resin of molecular weights 400 and 1000 was also carried out under different conditions. On curing with triethylenetetramine and baking, the resulting compositions were found to be hard, smooth, glossy and flexible and possessed good resistance to water, chemicals and solvents. When toluene diisocyanate was used as a curing agent even air-dried films showed similar behaviour. Further investigation was carried out by taking hydrolysed lac and epoxy resin in the ratio of 2:1 and dissolving

in a mixture of butanol and xylene (1:1 v/v). The solution was refluxed in the presence of dicyanadiamide (1% on the weight of solid) for 20 hr and acid values determined periodically. It was found that the acid value dropped from 97·30 to 19·10 after 20 hr.

So far, the experiments were carried out using the conventional hydrolysed lac prepared in aqueous medium where water-soluble portion of the hydrolysed lac (nearly 30%) is washed away and lost. Another set of experiments was carried out using total hydrolysed lac prepared in alcoholic medium. Total hydrolysed lac was compounded with epoxy resin by fusing them together in different proportions at 150°C as well as by refluxing in solvent (butanol + xylene 1:1 v/v). It was found to behave more or less like the conventional hydrolysed lac. The properties of the baked and air-dried films were studied. Baked films were quite hard, glossy and highly flexible.

(B. B. Khanna and S. K. M. Tripathi)

(b) RESEARCHES ON HAND

3.1 Fundamental Studies

3.1.1 Macrocyclic molecules from aleuritic acid

(i) *Synthesis of threo-9,10-dihydroxypalmitic acid and its conversion to erythro isomer*

Threo-aleuritic acid (9,10,16-trihydroxypalmitic acid) was converted to its methyl ester (m.p. 71-72°) [IR: 1740 cm^{-1}]. The ester was treated with dry acetone and conc. sulphuric acid to give isopropylidene derivative. ω-Hydroxyl of the isopropylidene derivative was then tosylated with tosylchloride in dry pyridine and was kept at −5°C for 16 hr. The tosyl derivative when refluxed with sodium iodide in dry acetone afforded oily iodocompound which was then treated with methanolic hydrochloric acid (1 N; 3 hr) to yield methyl 16-iodo-9,10-dihydroxypalmitate (m.p. 68-70°C).

The reduction of the iodocompound was carried out with sodium borohydride in dry dimethylformamide at 100°C for 1 hr. After removing excess of solvent under reduced pressure, water was added. The reaction product was, thereafter, extracted with ether and dried. Removal of the solvent afforded the ester as an oil which on alkaline hydrolysis and acidification yielded *threo*-9,10-dihydroxypalmitic acid. On crystallization from ethyl acetate, it melted at 85-87°C and analysed for $C_{16}H_{32}O_4$.

TLC in solvent system — ethyl acetate: acetic acid (100: 1, v/v) gave single spot above that of *threo*-aleuritic acid (R_f value 0·60 and 0·71 respectively).

Threo-9,10-dihydroxypalmitic acid was reacted with conc. hydrochloric acid and converted to the *erythro* acid according to the method described earlier (A.R.: 1974-76). The resulting *erythro* acid, after crystallization from ethyl acetate, melted at 119-121°C.

The *erythro* isomer, thus prepared, on similar treatment yielded the *threo*-isomer (m.p. 84-86°C). The yield in this case was, however, lower (60%) than the earlier conversion (90%).

(ii) *Synthesis of 7-hydroxytetradecanoic acid*

Heptyl magnesium bromide was prepared by treating *n*-heptylbromide with finely divided magnesium in dry ether for 3 hr. The resultant product was

condensed with cycloheptanone, left overnight, decomposed with saturated ammonium chloride solution and extracted with ether. Removal of solvent afforded the tertiary alcohol as liquid (IR: OH, 3400 cm^{-1}). The above alcohol was oxidized with chromic acid in acetic acid (glacial) and, after usual processing, yielded 7-oxo-tetradecanoic acid (m.p. 62-64°C) [IR: CO, 1720 cm^{-1} and COOH, 1700 cm^{-1}].

The reduction of the keto-ester by sodium borohydride in rectified spirit, yielded methyl 7-hydroxytetradecanoate (m.p. 54-55°C). The hydrolysis of the hydroxyester with methanolic alkali followed by acidification furnished 7-hydroxy-tetradecanoic acid (m.p. 51-53°C) [IR: OH and COOH 3400, 1710, 1700 cm^{-1}].

(iii) *Resolution of aleuritic acid by* (+) *cinchonine*

Aleuritic acid was dissolved in methanol and cinchonine added. The mixture was heated and the solution kept at 5°C. The cinchonine salt separated out and it was decomposed with hydrochloric acid. On working up (−) isomer of aleuritic acid was recovered which melted at 98-100°C. The (+) isomer was separated from the mother liquor and had a m.p. 99-100°C. The technique could also be applied to resolve synthetic butolic acid into (+) and (−) isomers.

(R. N. Majee, J. N. Chatterjea and S. C. Sengupta)

3.1.2 Detailed study on lac wax

The fractionation of whole lac wax by petroleum ether into two fractions and isolation of an ester (m.p. 93-94°C) from the insoluble fractions were reported earlier. The ester on hydrolysis afforded the corresponding alcohol (m.p. 82-83°C) and acid (m.p. 83-84°C) (A.R.: 1974-76).

(i) *Preparation of methyl ester*

The above acid was methylated by refluxing with dry methanol using conc. sulphuric acid as catalyst for 30 hr. The methyl ester had a m.p. 76-78°C. The R_f values for acid and ester were found to be 0·04 and 0·60 respectively in the solvent system: trichloroethylene: chloroform: acetic acid (70: 28: 0·5; v/v). The IR spectra for acid showed absorption at 1710 cm^{-1}, while for ester at 1750 cm^{-1}.

(ii) *Refractionation of alcohol soluble fraction at* 40°C (*Fraction C*)

The fractionation of whole lac wax by alcohol into three fractions A, B, C was reported earlier (A.R.: 1974-76). The alcohol-soluble fraction at 40°C (fraction C) was fractionated by chloroform into two fractions (a) soluble and (b) insoluble at room temperature (30°C). Both the fractions were further fractionated by ethyl acetate and two fractions (a_1 and a_2) and (b_1 and b_2) were obtained in each case as solubles and insolubles at room temperature (30°C). The TLC results of the fractions are listed below (Table 29).

Fraction B which was the major fraction (60% on the wt of alcohol soluble fraction at 40°C) was further fractionated into three fractions on silica column. Their R_f values are reported below (Table 30).

(iii) In order to obtain various fractions in large quantity, the whole lac wax was fractionated quantitatively by alcohol, acetone and petroleum ether (b.p. 60-80°C). The acid values of various fractions were also determined (Table 31).

TABLE 29 — R_f VALUES OF THE COMPONENTS PRESENT IN THE FRACTIONS OBTAINED FROM THE ALCOHOL SOLUBLE FRACTION OF LAC WAX

Fractions	R_f values of the components						
Fr. C	0·12	0·30	—	0·40	0·50	0·62	0·71
a	0·13	—	—	—	0·52	0·66	0·77
b	0·13	0·32	0·38	0·45	0·54	0·66	0·78
a_1	0·13	—	—	—	0·52	0·66	0·77
a_2	0·13	—	—	—	0·52	—	—
b_1	0·13	—	—	0·45	0·52	—	0·77
b_2	0·13	0·34	0·38	—	0·52	0·66	0·77

TABLE 30 — R_f VALUES OF THE COMPONENTS PRESENT IN THE FRACTIONS OBTAINED FROM FRACTION B

Fractions	R_f values of the components			
B_1	—	0·48	0·54	0·76
B_2	0·14	0·48	0·54	0·76
B_3	—	—	—	0·76

TABLE 31 — PERCENTAGE COMPOSITION AND ACID VALUES OF WAX FRACTIONS

Solvent used for fractionation	Condition	Amount (%)	Acid value
1. Petroleum ether (b.p. 60-80°C)	i) Insoluble at 25°C	44·9	7·2
	ii) Soluble at 25°C	55·1	1·2
2. Acetone	i) Insoluble at boiling temp.	44·0	2·4
	ii) Insoluble at 25°C	20·5	2·9
	iii) Insoluble at 5°C	28·5	1·7
	iv) Soluble at 5°C	7·0	8·4
3. Alcohol	i) Insoluble at boiling temp.	16·0	nil
	ii) Insoluble at 40°C	44·0	1·08
	iii) Soluble at 40°C	40·0	8·0
4. Whole wax	—	—	7·2

(K. M. Prasad, J. N. Chatterjea and S. C. Sengupta)

3.1.4 Separation and study of components of lac resin

(i) The isolation and characterization of the new terpenic acid, obtained from B-3 fraction of the hard resin was continued. 2:4-Dinitrophenylhydrazone of the new acid was readily prepared in alcoholic medium. The hydrazone melted at 114°-115°C. The formation of hydrazone confirmed the earlier finding from IR spectrum that the acid possesses an aldehyde group. Its acid value was found to be 219·7 which indicated that the molecular weight of the compound is nearly 255. In order to study its other characteristics and to put forward a structure, a method has been evolved to prepare it directly from sticklac in sufficient quantity.

Method —Sticklac (100 g) is taken and dissolved in ammonia solution (1 litre, 10% aqueous) by warming. The resulting solution is filtered to

remove insolubles and neutralized with sulphuric acid (10%). The aqueous portion is separated and the gummy mass is repeatedly washed with water. The mother-liquor together with the washings is extracted with ethylacetate and the extract dried over sodium sulphate and finally distilled over to get a viscous mass. This mass is repeatedly extracted with chloroform and about 1 g of the purified new terpenic acid is obtained.

(ii) The estimation of aleuritic and jalaric acids in hard resin was reported earlier (A.R.: 1971) and the average values were 36% and 39% respectively. In order to make this finding more conclusive, an estimation was made with a mixture of aleuritic and jalaric acids (1:1, w/w) after heating with potassium hydroxide solution (aqueous, 5%) at waterbath temperature for 5 hr. The estimation of aleuritic and jalaric acids in the resultant product was carried out by periodic acid and sodium sulphite methods respectively and their contents were found to be 37% and 40% respectively. This is in good agreement with the previous findings for hard resin. Thus, it will be evident that in hard resin, the ratio of aleuritic and jalaric acids is nearly 1:1 (w/w). The results indicate that some secondary reaction takes place during heating with potassium hydroxide.

(iii) The acid and carbonyl values of hard resin fractions obtained by urea-complex formation were also determined utilizing standard methods and are given below (Table 32).

TABLE 32 — ACID AND CARBONYL VALUES OF HARD RESIN FRACTIONS

Constant	Fractions				
	A	B-1	B-2	B-3	C
Acid value	84·0	82·0	62·0	100·0	80·0
Carbonyl value	16·8	17·5	16·5	19·0	14·5

The values shown in the table indicate the presence of components having free carboxyls in hard resin fractions. The well known reaction of hydrazine hydrate with acid, ester and carbonyl groups to give hydrazide and hydrazone respectively was utilized to identify the above components present in hard resin fractions. The method was first standardized by preparing aleurityl hydrazide (m.p. 134-135°C) by reacting methyl aleuritic and hydrazine hydrate. Thereafter each hard resin fraction was reacted with hydrazine hydrate to get hydrazide or hydrazone or mixture of both. The products obtained, however, did not melt sharply (charring at 170-175°C) which indicated them to be mixtures.

(N. Prasad)

3.1.5 Estimation of shellac in presence of other resins

(i) The volumetric method developed earlier (A.R: 1974-76) for the estimation of aldehydic acids (jalaric/*lacci*-jalaric acids) in lac was applied to different synthetic resins such as phenol-formaldehyde, urea-formaldehyde and melamine-formaldehyde. The water soluble portion obtained by partial hydrolysis of the above resins was subjected to the estimation of aldehydic acid and nil value was obtained for all of them.

(ii) An attempt was also made to evolve a spectronic method for the estimation of aldehydic (jalaric/*lacci*-jalaric) acids in lac. The method of 2:4-dinitrophenylhydrazone (DNP) [Sukh Dev *et al. Tetrahedron* **26**, 1970, pp. 4167-75] which depends on finding the absorption maxima (λ_{max}) of its alkaline solution was adopted. The absorption maximum (λ_{max} 480 mμ) of the alkaline solution of 2:4-DNP has specific intensity ε 480 $= 2{\cdot}72 \times 10^4$. Similarly, the alkaline solution of 2:4-DNP of jalaric acid at λ_{max} 480 mμ has specific intensity ε 480 $= 1{\cdot}21 \times 10^4$. These values were employed for estimating jalaric/*lacci*-jalaric acids in lac resin. The method developed is as follows:

Method — Dewaxed lac (1 g) is taken and partially hydrolysed with caustic soda (0·5 N aq.) and water soluble portion separated after decomposing the hydrolysed product with a mineral acid. The aqueous portion is collected in a measuring flask (100 ml) and the water insoluble gummy mass is thoroughly washed and all the washings collected in the same flask. Finally, the volume is made up to the mark by the addition of distilled water. Aqueous portion (5 ml) is taken in a conical flask and aldehyde free alcohol (25 ml), 2:4-DNP solution (alcoh. 1 ml) and conc. hydrochloric acid (one drop) are added. The mixture is heated for 3 hr at 50-60°C. After cooling, potassium hydroxide solution (alcoh. 5 ml) is added to it, whereupon a wine-red solution is obtained. A blank is also run side by side and λmax for these solutions are determined. The alkaline solution of 2:4-DNP of dewaxed lac at λ_{max} 480 mμ has specific intensity ($\epsilon = 1{\cdot}92 \times 10^4$). By calculation the percentage of aldehydic acids in dewaxed lac comes to 36·5.

(B. B. Khanna and N. Prasad)

3.2 Modification of Shellac/Constituents

3.2.2 Ion exchange resin from shellac

The cation exchange resin developed from shellac was got evaluated at Central Salt and Marine Chemicals Research Institute, Bhavnagar (Gujarat). It has been reported that the resin has certain drawbacks, such as, low attrition resistance, appreciable colour throw, small particle size, slow rate of exchange and lower degree of column utilization or breakthrough capacity. During the period under report, some of these drawbacks were removed as under:

(i) *Attrition resistance and rate of exchange*

The resin was properly packed in the column and washed with upward flow of water till no air bubbles were left and air channels were removed. By doing so, it was observed that the rate of exchange increased manyfold.

(ii) *Colour throw*

The colour throw of the resin was overcome by subjecting the resin to two types of treatment:

(a) The resin was washed with sodium carbonate (4%) and then equilibrated with sulphuric acid (4%), washed free of acid and dried at room temperature. The resultant product gave slight colouration with spirit and some other solvents.

(b) The air dried resin was taken in a big size soxhlet and extracted with spirit for 8 hr. The resin when washed and dried at room temperature was found to give no colour with the usual solvents.

(iii) *Breakthrough capacity or degree of column utilization*

The cation exchange capacity of the resin in terms of g. meg of dry resin was determined and the stage, where leakage of cations started, was determined.

It was observed that the breakthrough capacity or degree of column utilization increased from 48 to 71 per cent. However, the result needs confirmation by other methods.

(P. R. Bhattacharya and A. Rehman)

3.2.4 Creation of unsaturation in aleuritic acid and its addition polymerization

Attempts were continued to prepare unsaturated derivatives of aleuritic acid by reacting it with allyl alcohol/cinnamic acid/crotonic acid in the presence of hydrochloric acid (1%) for 1 hr at 84°C. In case of crotonic acid, benzene was used as a solvent. The product was washed with distilled water, dried over sodium sulphate and crystallized from ether. The properties of the resultant unsaturated derivatives are given in Table 33.

TABLE 33 — PREPARATION OF THE UNSATURATED DERIVATIVES OF ALEURITIC ACID AND THEIR PROPERTIES

Aleuritic acid (g)	Allyl alcohol (ml)	Crotonic acid (g)	Cinnamic acid (g)	Characteristics of the product	m.p. °C	Acid value	Hydroxyl value	Iodine value
10	25	—	—	Amorphous sticky solid	53	0	46·2	70·5
10	—	10	—	White solid	50-55	149·3	293·0	52·0
10	—	—	10	White solid	160-165	120·0	234·7	60·3

Polymerization of allyl aleuritate

Allyl aleuritate (2·59 g) in benzene (100 ml) was polymerized with benzoyl peroxide (1% on the weight of solid) at 84°C. The resultant product, so obtained, was a white solid (m.p. 55°C). The acid and iodine values were nil while the hydroxyl value was 18·6.

(A. Kumar and M. K. Mishra)

3.2.7 Polyesters from aleuritic acid

(1) Last year an attempt was made to prepare polyesters by the reaction of acetonated 1,16-dicarboxylic acid (obtained from aleuritic acid) with ethylene glycol but was unsuccessful. It is presumed that during the course of the reaction, the blocked vicinal hydroxyls are freed. Hence attempts were made to replace the hydroxyl groups as mentioned below:

(a) To prepare the halogenated derivative, the dihydroxy dibasic acid was treated with phosphorus and iodine. The product obtained was spongy and insoluble in the organic solvents.

(b) To prepare the unsaturated derivative, the dihydroxy dibasic acid was treated with phosphonium iodide in carbon disulphide or with phosphorus tribromide in ether. The desired product, however, could not be obtained.

(c) The dihydroxy dibasic acid was treated with acetic acid (glacial) to replace the vicinal hydroxyls with acetate (HC_3COO) group. I.R. spectrum showed the presence of the hydroxyl groups in the product indicating that the attempt was not successful. It is now proposed to carry out acetylation with acetic anhydride.

(2) An attempt was made to prepare 9,10-dihydroxy 1,16-dicarboxylic acid from methyl aleuritate instead of aleuritic acid to see whether an increased yield could be had following the same principle (acetonation of vicinal hydroxyl groups and oxidation of the end hydroxyl group) as used by Nagel. However, this did not give the desired result.

(A. Kumar and R. N. Das)

3.2.8 Modification of lac and hydrolysed lac with glycols and dicarboxylic acids

Coatings based on polyurethanes have very good flexibility, adhesion, impact and solvent resistance. Polyurethane coatings also find a variety of outdoor and marine uses because of their good weatherability.

Shellac has got certain drawbacks for coating compositions like brittleness, low softening point, poor resistance to water and chemicals. The object of the project is to prepare shellac based polyurethane coatings by first modifying shellac with glycols and dicarboxylic acids for chain extension and reacting the resultant polyesters with isocyanates.

The polyesters were prepared by reacting shellac with ethylene glycol (1:6 molecular proportion) and different proportions of dicarboxylic acids by two methods. In the first method, the polyesters were prepared in one step by taking shellac, ethylene glycol and adipic acid at the same time. *p*-Toluene sulphonic acid was used as a catalyst and the reaction mixture was refluxed at $170 \pm 5°C$ with constant stirring up to 8 hr.

In another method, polyesters were prepared in two steps — first by preparing ethylene glycol ether ester of shellac in the presence of the *p*-toluene sulphonic acid and then reacting with different proportions of adipic acid. The acid values of various polyesters were, thereafter, determined. It was observed that lower acid values were obtained in one-step process (Table 34).

In a similar manner, shellac-based polyesters with terephthalic acid, phthalic acid and maleic anhydride were prepared adopting one-step process.

(B. B. Khanna and K. N. Rao)

3.2.9 Modification of lac, its fractions and hydrolysed lac with sulphur

Life under heat of dewaxed lac, *kusmi* lac and hydrolysed lac was determined at 150°C. These were separately reacted with sulphur (5 and 10% on the weight of lac) at 150°C for different duration of time up to pregelation stage. The amount of sulphur in these resultant products was, thereafter, determined by preparing solution in spirit and filtering off unreacted sulphur and is reported in Table 35.

Next, these lac samples were heated with sulphur (5%) in the presence of mercaptobenzothiazole (M.B.T.) (1%), a rubber accelerator, at 150°C and the amount of sulphur reacted was estimated which showed an increasing trend in all cases.

TABLE 34 — PREPARATION OF SHELLAC-BASED POLYESTERS AND THEIR PROPERTIES

(*Heating period*: 8 *hr*; *temperature*: 170+5°C)

Expt. No.	Shellac (g)	Catalyst (g)	Diethylene glycol (g)	Ethylene glycol (g)	Adipic acid one-step process (g)	Adipic acid two-step process (g)	Tereph-thalic acid one-step process (g)	Phthalic acid one-step process (g)	Maleic anhydride one-step process (g)	Acid value
1	100	0·5	—	38	—	—	—	—	—	32·41
2	100	0·5	—	38	—	10	—	—	—	34·01
3	100	0·5	—	38	—	15	—	—	—	42·61
4	100	0·5	—	38	—	25	—	—	—	57·82
5	100	0·5	—	38	10	—	—	—	—	19·45
6	100	0·5	—	38	15	—	—	—	—	20·18
7	100	0·5	—	38	20	—	—	—	—	32·68
8	100	0·5	—	38	—	—	10	—	—	27·98
9	100	0·5	—	38	—	—	20	—	—	41·48
10	100	0·5	—	38	—	—	—	10	—	43·04
11	100	0·5	—	38	—	—	—	20	—	56·63
12	100	0·5	—	38	—	—	—	—	10	48·48
13	100	0·5	54	—	10	—	—	—	—	28·35
14	100	0·5	54	—	15	—	—	—	—	28·05
15	100	0·5	54	—	20	—	—	—	—	37·68

TABLE 35 — AMOUNT OF SULPHUR COMBINING WITH VARIOUS TYPES OF LAC

Type of lac used	Life under heat (min)	Sulphur used for reaction (%)	Period of reaction (min)	Sulphur combined (%)
Dewaxed	18	0	—	—
do	17	5	15	1·7
do	17	10	15	1·8
Kusmi	36	0	—	—
do	34	5	30	3·5
do	34	10	30	3·5
Hydrolysed	70	0	—	—
do	68	5	60	3·6
do	67	10	60	3·7

The chemical constants of the sulphur reacted lac samples are reported in Table 36.

A study of the table would indicate that there is a drop in all the three constants, viz., acid, hydroxyl and iodine values [IR: S — containing groups 1220-1240 cm^{-1}].

Next, aleuritic acid, the chief constituent of lac, was reacted with sulphur at 150°C for 4 hr (its life under heat was more than 7 hr) and it was found out that the reacted sulphur was nearly 4 per cent.

TABLE 36 — PROPERTIES OF SULPHUR MODIFIED LACS

No.	Samples	Sulphur combined (%)	Acid value	Hydroxyl value	Iodine value
1	Dewaxed lac	—	65·6	280·32	15·2
2	Dewaxed lac reacted with sulphur	1·7	62·72	270·5	9·36
3	do+accelerator	3·2	62·9	255·6	9·36
4	*Kusmi* lac	—	65·17	277·2	14·5
5	*Kusmi* lac reacted with sulphur	3·5	62·5	257·3	10·2
6	do+accelerator	3·8	61·9	255·2	10·3
7	Hydrolysed lac	—	122	292·8	—
8	Hydrolysed lac reacted with sulphur	3·6	116	277·5	—
9	do+accelerator	4·2	115·7	—	—

(B. B. Khanna and Ashok Kumar)

3.3 Use of Shellac and Modified Shellac in Surface Coatings

3.3.3 Studies on lac-oil combinations and their utilization

Experiments were carried out last year to replace alkali refined linseed oil by double-boiled linseed oil for preparation of the lac-oil varnishes which could be thinned with hydrocarbon solvents without turbidity and produced hard, smooth and glossy films on air drying. These films showed much improved performance in respect of drying characteristic and water resistance.

Further experiments were undertaken to prepare the varnish in bigger lots (up to 1·5 litres). Though the varnish could be prepared without any difficulty, the films showed some deviation in performance. In this case, the films took slightly longer time for air drying (tack-free), i.e., 2·5 hr instead of 1·5 hr. Some deterioration was also noted in regard to gloss, adhesion and hardness of the films. These varnishes could also be pigmented and gave similar performance.

Electrical properties of these varnishes were, thereafter, determined. The breakdown strength (BDS) of the samples with and without drier at 27°C was found to be 3 kV/mil and 2·5 kV/mil respectively.

In view of the high BDS of this varnish, its suitability as a baking type insulating varnish was also assessed. It has been found that beside high BDS, this varnish possesses many desirable characteristics of a baking type insulating varnish. It air dries within 2 hr and produces hard, nontacky and smooth films. It is compatible with thinners, possesses the desired solid content and thermosetting characteristics.

Experiments are in progress to test the other important properties as mentioned in the IS:350 for baking type insulating varnish.

(S. Kumar and M. Mukherjee)

3.3.6 Shellac based paint/primer for the gas holder of gobar-gas plant

Investigations carried out to find the suitability of shellac/epoxy resin and shellac-linseed oil-toluene diisocyanate compositions for the gas holders of gobar-gas plants were reported last year. Performance of these compositions under laboratory conditions was further examined.

The composition based on shellac-linseed oil-toluene diisocyanate showed very little deterioration even after one and a half year immersion in gobar-slurry under laboratory conditions. The composition based on shellac epoxy resin was, however, affected after one year.

The compositions will now be tested on actual gas holders of gobar-gas plants.

(S. K. M. Tripathi and B. B. Khanna)

3.4 Use of Lac for Encapsulation

3.4.1 Coating of insecticides/pesticides with lac

As reported earlier (A.R.: 1974-76), two chemical and one physical methods of encapsulation have been developed using lac as a wall material.

In order to develop a mechanical method of coating solid insecticides/pesticides, a coating apparatus based on fluidized-bed technique was suitably modified. It was tried with the air compressors available in the Institute. However, due to insufficient air pressure, the coating experiments could not be done. Efforts are being made to procure another suitable air compressor.

(S. Kumar, B. C. Srivastava and C. P. Malhotra)

3.4.2 Physico-chemical studies on lac for encapsulation

Systematic studies on lac hydrosols were initiated in order to use lac as a suitable wall material for encapsulation. Hydrosols of dewaxed lemon shellac (from 5 to 15% w/v, aqueous ammonical solutions (0·5 N) were prepared by adopting dialysis technique using cellophane paper and continuous flow of water. Similarly, hydrosols of DL-Shellac (from 5 to 15% w/v, spirit solutions) were prepared by pouring alcoholic solution in excess of boiling water by agitation. The physico-chemical properties, such as, resin concentration, *p*H, nature of charge and specific conductivity were determined for both sols and solutions.

Hydrosols obtained by dialysis technique have *p*H around 7 but those prepared by the other method have acidic range 4-5. Further, hydrosols obtained by dialysis technique are more concentrated in comparison to the other hydrosols. Hydrosols obtained by dialysis technique are less conductive than those obtained by the other method. The nature of charge in all the cases was found to be negative. It has been observed that *p*H may serve as a basis for sol formation by the dialysis technique. Preliminary experiments have shown that hydrosols of bleached lac having light colour can also be prepared by the dialysis technique. The glass apparatus both for electrodialysis and electrophoresis were got fabricated and ion exchange membrane was procured.

(S. Kumar, B. C. Srivastava and P. K. Banerjee)

3.5 Use of Shellac in Rocket Fuel

It was reported earlier that by using a modified composition, smooth and compact shellac propellants were obtained which also possessed adequate flexibility. This flexibility however lasted for 15-20 days.

During the period under report further experiments were carried out to improve the flexibility of shellac propellants. For this purpose shellac was modified with a polyester resin in the presence of a plasticizer. The liquid binder so obtained was mixed with oxidisers, hardner, catalyst, etc., casted in the mould and cured at 120°C for 24 hr. The solid propellants so obtained were smooth and compact and possessed improved flexibility. When tested for burning properties, these propellants burnt smoothly and vigorously but gave a slightly smoky flame.

For another set of experiments, hydrolysed lac was modified with a thermosetting resin having free functional group. This modified binder when mixed with oxidizer etc. produced propellants which were flexible but comparatively softer. These propellants when tested for burning properties, burnt smoothly and vigorously with luminous flame and left no ash.

The calorific value of shellac propellants prepared earlier was determined and found to be 1134 calories/gm.

(S. Kumar and A. K. Dasgupta)

3.7 Electrical Properties of Lac and Modified Lacs

3.7.1 Study on the dielectric behaviour of natural resins

The Cole-Cole method has been found to be very useful in obtaining information about the different relaxation processes and the conformational changes occurring in the resin, Manila copal, during its thermal transition from the solid to the liquid state (A.R: 1974-76). During the year, an analysis of the dielectric data of shellac, obtained earlier by Bhattacharya [*Indian J. Phys.*, **18**, 1944, p. 1] was made by the same Cole-Cole method in the frequency range 50 Hz-500 kHz and at temperatures 20° to 110°C. The Cole-Cole (ϵ'' vs ϵ' plots) patterns of shellac at different temperatures are shown in Figs. 1A and 1B.

It may be noticed that the dielectric relaxation of shellac for temperatures 20° to 60°C are comprised of three relaxation processes (marked I, II and III). The dielectric relaxation of the resin at 70°C afforded two dispersion processes. At temperature 80°C and above, it represented perfect semicircular Cole-Cole patterns.

The various dielectric parameters determined from the Cole-Cole diagrams at different temperatures along with the experimentally obtained values are given in Table 37. At temperatures for which both the ϵ_0 and ϵ_∞ values could not be obtained from the Cole-Cole diagrams, the dielectric increment ($\Delta\epsilon$) values were determined from the observed values. The variation of the static dielectric constant (ϵ_0) with temperature (Fig. 2) showed an increase from 3·7 at 20°C to 8·13 at 80°C and then decreased to a value of 7·26 at 110°C. The glass transition and melting temperatures were found to be around 40°C and 70°C respectively. An increase of nearly six times in dielectric increment $\Delta\epsilon$, which is related to the dipole moment, was obtained owing to the increase of temperature

TABLE 37 — DIELECTRIC PARAMETERS OF SHELLAC DERIVED FROM THE COLE-COLE DIAGRAMS AT DIFFERENT TEMPERATURES

Temperature °(C)	Low frequency dielectric constant (ϵ_0)		High frequency dielectric constant (ϵ_∞)		Dielectric increment $\Delta\epsilon$ (ϵ_0-ϵ_∞)	Relaxation time (sec) τ	Distribution parameter α
	Observed value (a)	From Cole-Cole diagram	Observed value (a)	From Cole-Cole diagram			
20	3·70		3·25	3·12	0·58		
30	3·91		3·34	3·20	0·71		
40	4·28		3·55	3·32	0·96		
50	4·95		3·90		1·05		
60	6·00		4·19		1·81		
70	7·12	7·90	4·49		3·41		
80	7·85	8·13	4·69	4·48	3·65	$5·50\times10^{-5}$	0·61
90	7·78	7·85	4·90	4·74	3·11	$8·74\times10^{-6}$	0·58
100	8·08	7·38	5·24	4·80	2·58	$1·80\times10^{-6}$	0·51
110	8·23	7·26	5·90	4·91	2·35	$2·00\times10^{-7}$	0·47

(a) Values obtained by Bhattacharya.

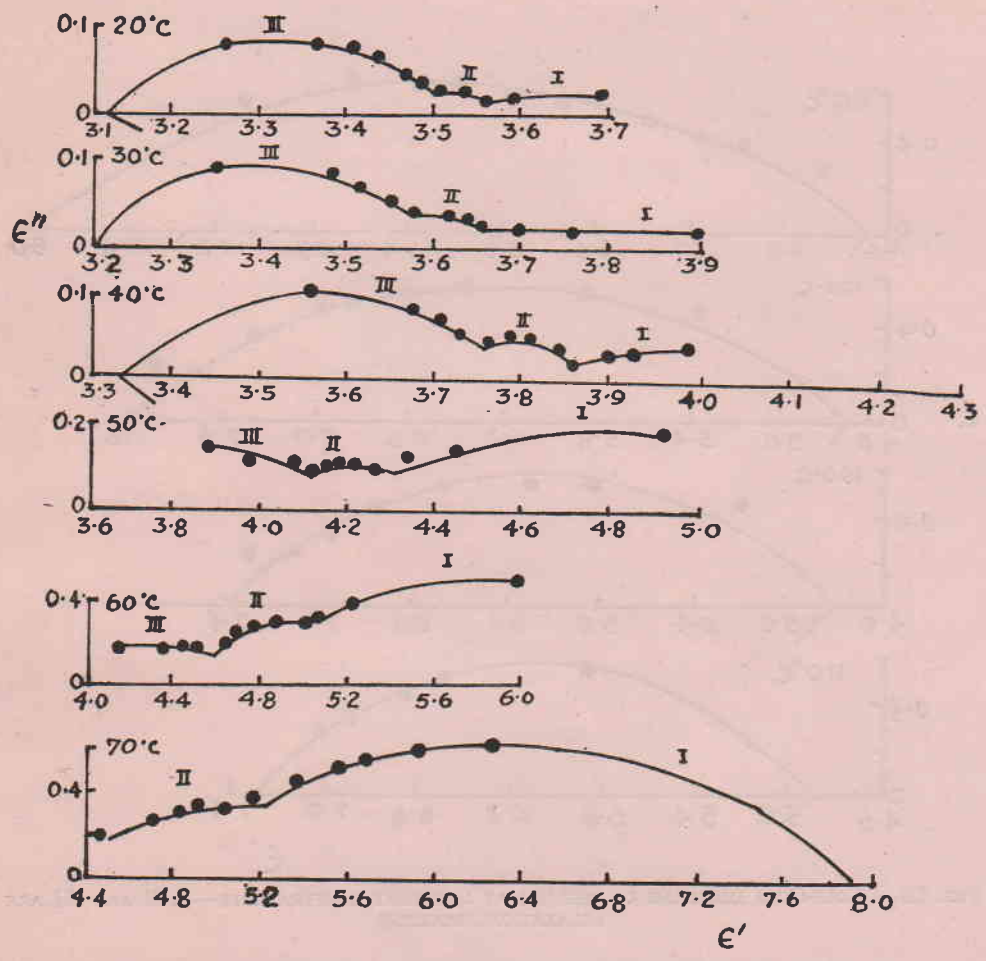

FIG. 1A — COLE-COLE DIAGRAMS OF SHELLAC AT DIFFERENT TEMPERATURES — I, II AND III ARE RELAXATION PROCESSES

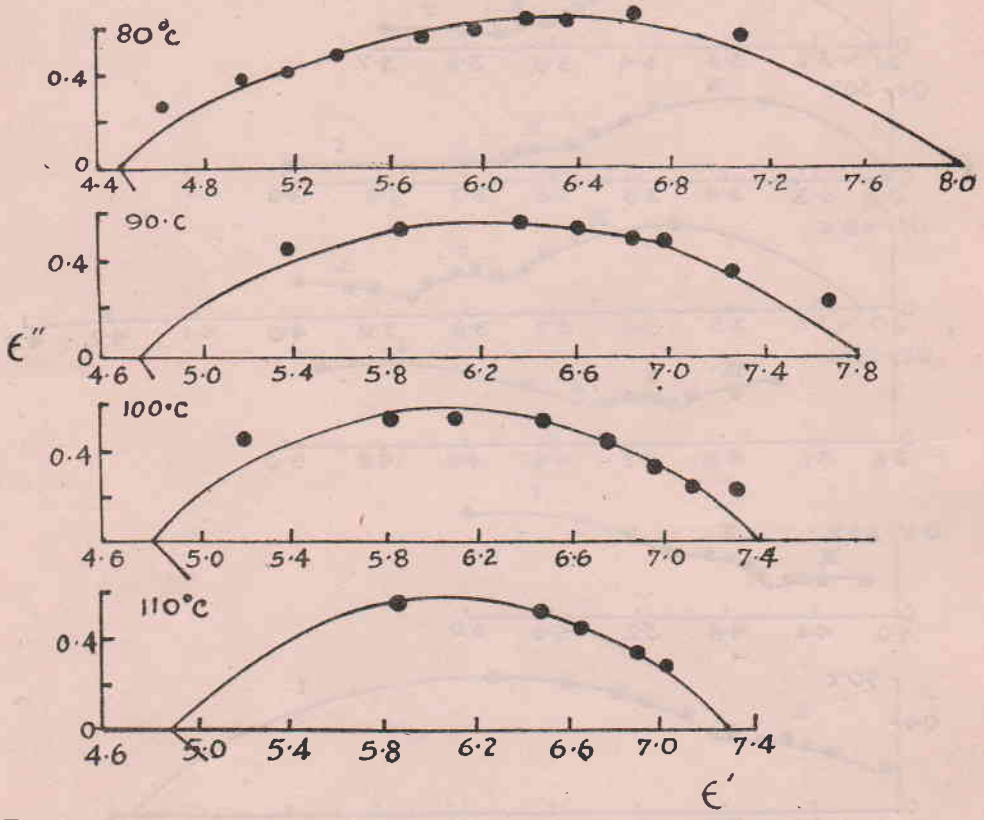

FIG. 1B — COLE-COLE DIAGRAMS OF SHELLAC AT DIFFERENT TEMPERATURES — I, II AND III ARE RELAXATION PROCESSES

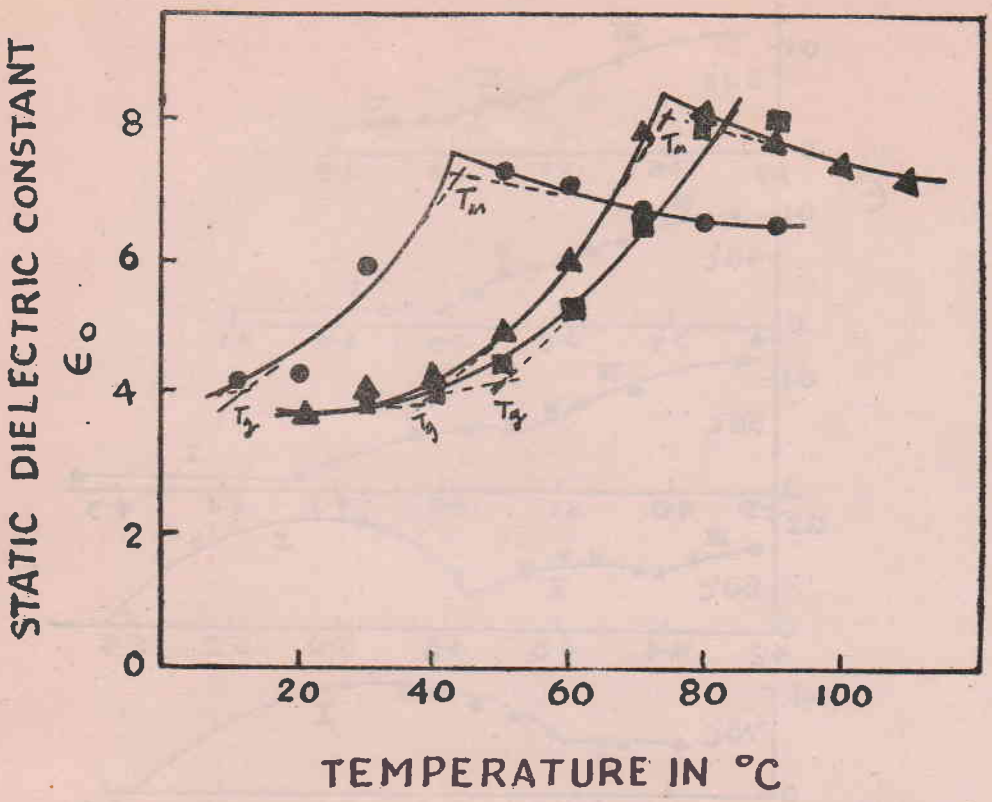

FIG. 2 — VARIATION OF STATIC DIELECTRIC CONSTANT (ϵ_0) WITH TEMPERATURE OF SHELLAC (—Δ—), SOFT FRACTION (— ● —) AND HARD FRACTION (— ■ —). T_g AND T_m DENOTE THE GLASS-TRANSITION AND MELTING TEMPERATURES RESPECTIVELY

from 20° to 80°C while a decrease of about 36 per cent was observed for further rise of temperature from 80° to 110°C. The values for relaxation time (τ) of shellac from 80° to 110°C were calculated from the Cole-Cole diagrams which decreased from $5{\cdot}5\times10^{-5}$ sec. at 80°C to 2×10^{-7} sec. at 110°C. Nearly 23 per cent decrease in the Cole-Cole distribution parameter (α) was noticed for a change in temperature from 80° to 110°C.

The different relaxation processes below the melting temperature were also analysed. One of the processes was attributed to be due to the relaxation of a polar group (possibly free hydroxyl) and other process from orientation of segments. The single Cole-Cole pattern obtained above 80°C indicated that the relaxation was possibly due to molecular motions. The early studies by Bhattacharya indicated only one process which was attributed to the relaxation of hydroxyl groups. The marked decrease in different parameters above the melting temperature (80°C) suggested some rearrangement in the conformation of the resin molecule.

The above study was then extended to the fractions of shellac. The Cole-Cole diagrams for both hard and soft resin fractions of lac were drawn

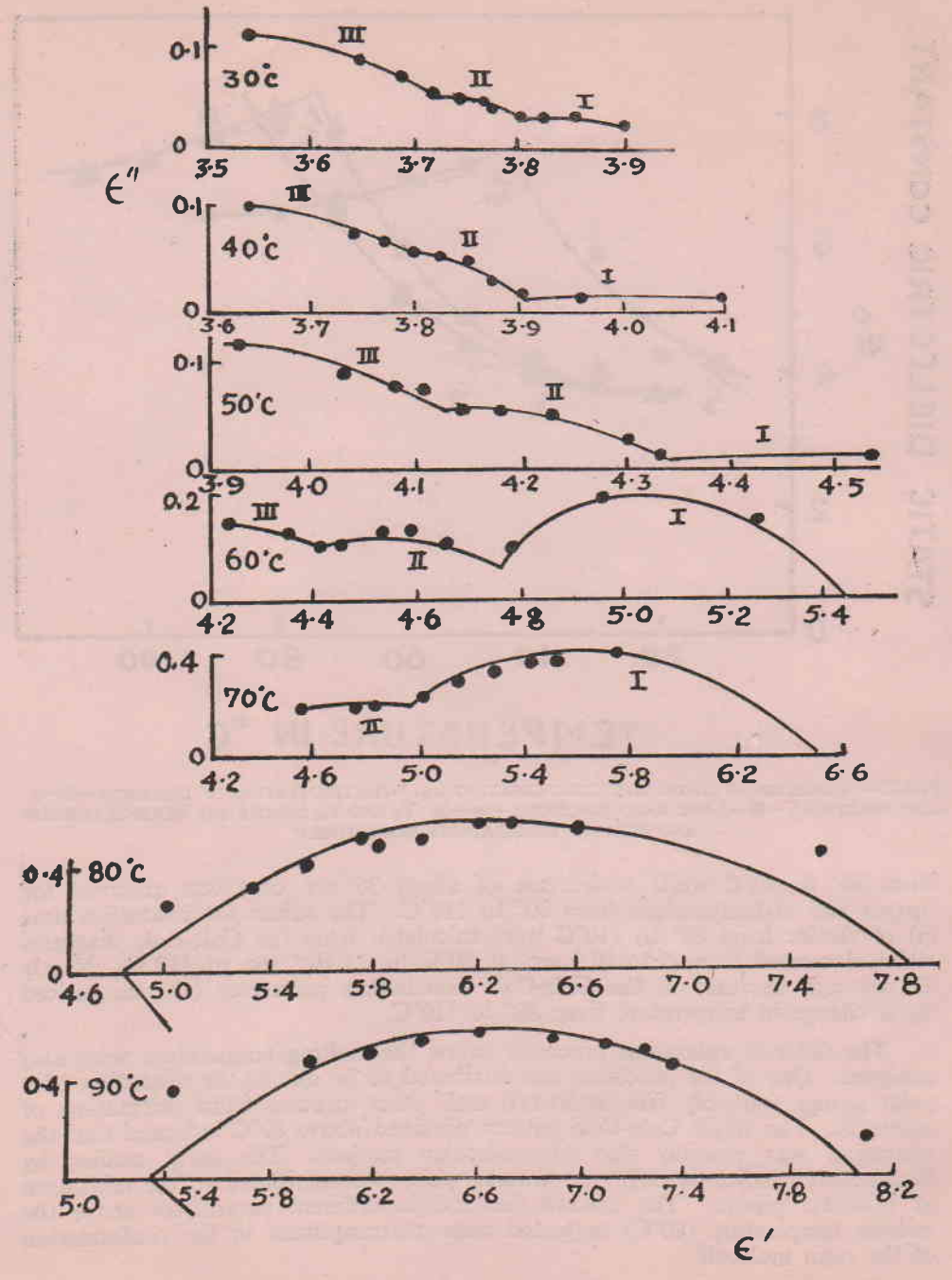

FIG. 3 — COLE-COLE DIAGRAMS OF HARD FRACTION AT DIFFERENT TEMPERATURES — I, II AND III ARE THE RELAXATION PROCESSES

using the data obtained by Bhattacharya [*Indian J. Phys.*, **18**, 97, 1944]. Hard resin which constitutes nearly 70 per cent of the whole lac also exhibited three relaxation processes between 20° and 60°C, two processes at 70°C and one (typical Cole-Cole patterns) at 80° and 90°C (Fig. 3). On the other hand, soft resin which comprises nearly 30 per cent of lac showed two relaxation processes from 10° to 40°C and one process between 50° and 90°C (Fig. 4).

The different dielectric parameters of soft and hard resins evaluated from the Cole-Cole diagrams have been shown in Tables 38 and 39 respectively.

TABLE 38 — DIELECTRIC PARAMETERS OF SOFT FRACTION EVALUATED FROM COLE-COLE DIAGRAMS AT DIFFERENT TEMPERATURES

Temperature (°C)	Low frequency dielectric constant (ϵ_0)		High frequency dielectric constant (ϵ_∞)		Dielectric increment $\Delta\epsilon$	Relaxation time (sec) τ	Distribution parameter α
	Observed value (a)	Obtained from Cole-Cole diagram	Observed value (a)	Obtained from Cole-Cole diagram			
10	4·20	4·20	3·35	3·08	1·12		
20	4·33	—	3·52	3·32	1·01		
30	5·80	—	3·74	3·54	2·26		
40	6·54	6·98	4·00	3·62	3·36		
50	6·92	7·18	4·22	4·02	3·16	$2·93\times10^{-5}$	0·63
60	6·90	7·08	4·60	4·24	2·84	$6·9\times10^{-6}$	0·58
70	6·72	6·82	5·00	4·48	2·34	$1·77\times10^{-6}$	0·49
80	6·51	6·57	5·33	4·62	1·95	$7·16\times10^{-7}$	0·49
90	6·40	6·44	5·56	4·99	1·45	$6·38\times10^{-7}$	0·32

(a) Values obtained by Bhattacharya.

TABLE 39 — DIELECTRIC PARAMETERS OF HARD FRACTION EVALUATED FROM COLE-COLE DIAGRAMS AT DIFFERENT TEMPERATURES

Temperature (°C)	Low frequency dielectric constant (ϵ_0)		High frequency dielectric constant (ϵ_∞)		Dielectric increment $\Delta\epsilon$	Relaxation time (sec) τ	Distribution parameter α
	Observed value (a)	Obtained from Cole-Cole diagram	Observed value (a)	Obtained from Cole-Cole diagram			
30	3·90	—	3·54	—	0·36		
40	4·10	—	3·64	—	0·46		
50	4·54	—	3·93	—	0·61		
60	5·24	5·37	4·23	—	1·14		
70	5·75	6·58	4·52	—	2·06		
80	5·56	7·90	5·00	4·80	3·10	$8·0\times10^{-5}$	0·57
90	8·13	8·10	5·41	5·28	2·82	$2·0\times10^{-5}$	0·52

(a) Values obtained by Bhattacharya.

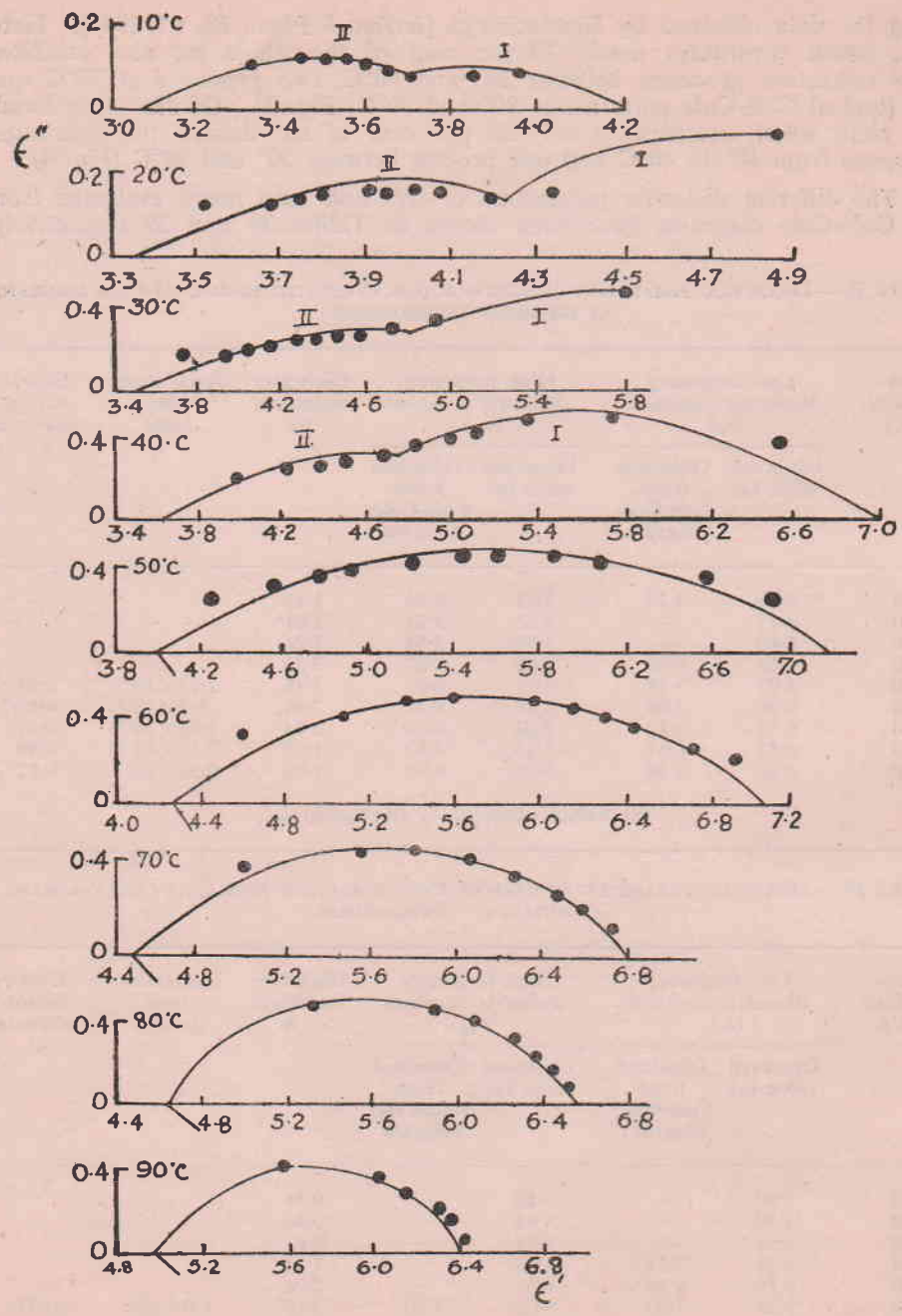

FIG. 4 — COLE-COLE DIAGRAMS OF SOFT FRACTION AT DIFFERENT TEMPERATURES — I AND II ARE THE RELAXATION PROCESSES

The variation of ϵ_0 with temperature for soft and hard resins and shellac has been shown in Fig. 2. For both the fractions, ϵ_0 showed an increase attaining maximum at 50°C and 70°C respectively and then decreased with further rise in temperature. Both the glass-transition and melting temperatures of hard resin were greater by 10°C while the corresponding temperatures for soft resin were about 30°C lower than those of shellac.

Between 10° and 60°C (where molecules probably do not undergo appreciable change in conformation), ϵ_0 values of soft resin were higher as compared to both hard fraction and shellac. This indicates that for the soft fraction the effective dipole moment per motional unit is greater than those of other. For temperature below 40°C, the nearly equal ϵ_0 values for both hard fraction and shellac suggest that the number of dipoles present in both the resins are the same. Marked decrease in dielectric increment, relaxation time and distribution parameter was noticed for both the fractions above their melting temperature.

Typical single Cole-Cole patterns were obtained for both hard and soft fractions above their melting temperature. The results suggest some rearrangement in the spatial distribution of the resin molecules above their melting temperatures. The decrease in relaxation time indicates increased compactness of the resin molecule at high temperature probably through cross-linking.

(D. N. Goswami)

3.7.2 Effect of plasticizers on the electrical properties of shellac

The effect of the addition of tricresyl phosphate (TCP), a plasticizer, on the dielectric strength of shellac varnishes (air drying) was investigated. Preliminary study was made on shellac varnishes (25% w/v) prepared with methanol. The preparation of the films from tissue papers and the method of measurement of dielectric strength were the same as described in IS: 352-1973. An increase of nearly 56 per cent in breakdown strength of shellac was obtained with the addition of TCP (on the weight of shellac). The air-dried films of plain shellac varnish were very brittle. The addition of TCP improved the flexibility to a certain extent. The baking (at 100°C for 2 hr) of the films improved the breakdown strength but the flexibility deteriorated.

The study was then extended to shellac varnishes prepared from spirit. The variation of breakdown strength with the concentration of TCP added in the varnish is shown in Fig. 5. The dielectric strength of air-dried (dried over fused calcium chloride for 24 hr) films of shellac was found to increase two-fold with the addition of 20 per cent TCP. The addition of more TCP (30%) did not produce any appreciable increase in the dielectric strength. The air-dried films of plain shellac were found to be very brittle. The addition of TCP improved the flexibility. The films made from 30 per cent TCP-treated shellac varnish were very flexible.

The effect of humidity on the dielectric strength was also studied after conditioning the films in a desiccator (50% R.H. for 24 hr). Humidity caused a decrease in the dielectric strength of shellac-TCP varnish films.

The maximum decrease in dielectric strength (17·5%) was observed with 30% TCP-treated shellac varnish films. The corresponding decrease in the breakdown strength with 20, 15 and 10% TCP-treated varnish films was 13·3, 10·4 and 7·5% respectively. The flexibility of the films kept under humid condition was comparatively better than those of the air-dried films.

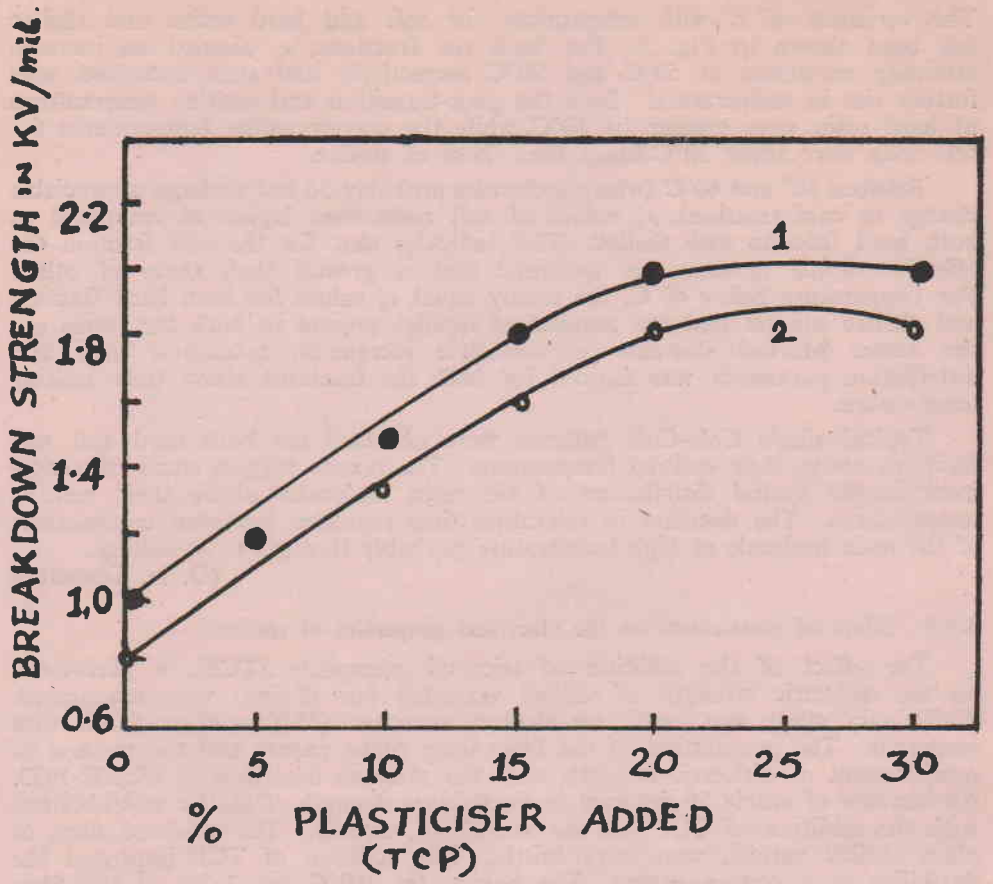

FIG. 5 — VARIATION OF BREAKDOWN STRENGTH OF SHELLAC FILMS WITH PERCENTAGE OF PLASTICIZER IN THE VARNISH [(1) AIR-DRIED, KEPT OVER ANHYDROUS $CaCl_2$ FOR 24 HR AT ROOM TEMPERATURE, (2) FILMS CONDITIONED AT 50% R.H. FOR 24 HR AT ROOM TEMPERATURE]

The flexibility of the films prepared from denatured spirit was better as compared to the films from methanol.

(D. N. Goswami)

(c) RESEARCHES CONTEMPLATED

Correlation of the properties of seedlac and shellac with age.

D. TECHNOLOGY DIVISION

(a) RESEARCHES COMPLETED

4.1.2 Correlation of the properties of shellac and seedlac

In trade different qualities of seedlacs are mixed in different proportions to obtain shellac of requisite standard. However, no scientific studies have been

made till now to correlate the properties, e.g., life, flow and colour of seedlac and shellac made therefrom.

Seedlacs of different qualities were taken and converted into shellac by *bhatta* process. These seedlacs were then mixed in different proportions and the mixtures were tested for their properties, such as, life, flow and colour index. These mixtures of seedlacs were also processed to shellac by the same method and their properties determined.

A number of such experiments have been carried out to draw definite conclusion.

On the basis of results obtained (A.R.: 1974-76), it can be said that the colour, life and flow of shellac are always better than those of the parent seedlac. These properties of shellac are dependent on the ratio in which the parent seedlacs are mixed. In a typical case when two seedlacs with life, flow and colour index of 45, 41, 16 and 52, 44, 12 respectively were converted into shellac, these values for the corresponding shellacs were 50, 78, 14 and 58, 61, 8. But when these seedlacs were mixed in the ratio of 3:2, these values for the resulting shellac were 53, 71 and 12. These results indicate that the life, flow and colour of the shellac prepared from mixtures of seedlac are directly proportional to the ratio in which the seedlacs have been mixed.

(A. K. Ghosh and R. K. Banerjee)

(b) RESEARCHES ON HAND

4.1 Improvement in the Processing Techniques

4.1.1 Manufacture of shellac and dewaxed lac in aqueous medium

A method which was standardized last year for preparation of shellac in aqueous medium was found satisfactory when tried on semi-pilot scale by taking 20 kg of seedlac per charge. In brief, the method is described below:

Seedlac is dissolved in water (1:4) using a mixture of sodium carbonate (8%) and sodium sulphite (3%) on the weight of seedlac and heating at 80°-85°C for half an hour. The solution is then filtered through a cloth bag to remove impurities. For the preparation of dewaxed lac, the solution is cooled at room temperature and the wax which separated out in the form of crust is removed. To remove as much wax as possible, the solution is then refiltered by passing through a cloth bag containing paper pulp as filtering aid. In order to get natural colour of product, sodium hydrosulphite (2%) on the weight of seedlac was added to the filtrate which is diluted to 5 per cent lac content and finally precipitated with dil. sulphuric acid (5%). The precipitated lac is then washed free from acid, boiled in water and molten mass is dried in steam heated pan. During drying, a mixture of hydrolysed lac and recinoleic acid (2% each on the weight of seedlac) is also incorporated by dissolving in a small quantity of spirit for better life and flow. It is then drawn in the form of sheet. Starting with a fresh *baisakhi* seedlac having life, flow and colour 56 min, 65 mm and 12·5 units, the final product was found to have corresponding values of 36-38 min, 47-49 mm and 11 to 12·5 units respectively. If the mixture of hydrolysed lac and recinoleic acid (2% each) is not added, the life, flow and colour are found to be 17 min, 11 mm and 12·5 units respectively.

(A. K. Ghosh)

4.1.5 Effect of drying seedlac in sun and shade

During the period, sixteen pairs of samples were subjected to drying in sun and in shade. The alcoholic solution (10%) of these samples were examined by comparing their colours with red, yellow and blue slides of the Lovibond Tintometer. The data are given in Table 40. It was observed that the samples dried in sun had red colour higher by 0·3-1·1 unit, the common range being 0·3-0·5, and other colours were the same as compared to samples dried in the shade. More samples are to be examined in order to confirm the results.

TABLE 40 — COLOUR ANALYSIS OF SEEDLAC SOLUTION BY LOVIBOND TINTOMETER

Sl No.	Seedlac	Method of drying	Colour index	Colour analysis by Lovibond Tintometer			
				Yellow	Red	Blue	Bright-ness
1	Rangeeni, Oct. 1972	Sun	20	14	8·5	×	×
		Shade	19	14	8·0	×	×
2	Rangeeni, June 1973	Sun	21	20	8·7	×	×
		Shade	21	20	7·6	×	×
3	Rangeeni, June 1974	Sun	17	20	6·9	×	0·4
		Shade	17	20	6·6	×	0·4
4	Rangeeni, July 1974	Sun	21	20	8·1	×	×
		Shade	21	20	7·4	×	×
5	Rangeeni, Jan. 1975	Sun	14	18	6·0	×	0·3
		Shade	13	18	5·5	×	0·3
6	Rangeeni, June 1975	Sun	20	20	8·2	×	0·4
		Shade	20	20	7·9	×	0·4
7	Rangeeni, Oct. 1975	Sun	17	20	6·5	×	0·4
		Shade	17	20	6·1	×	0·4
8	Rangeeni, Nov. 1975	Sun	20	20	8·0	×	0·4
		Shade	20	20	7·2	×	0·4
9	Rangeeni, Jan. 1976	Sun	16	20	6·5	×	0·3
		Shade	16	20	6·0	×	0·3
10	Rangeeni, June 1976	Sun	24	20	10·5	×	0·4
		Shade	22	20	9·4	×	0·4
11	Rangeeni, Oct. 1976	Sun	17	14	7·0	×	0·4
		Shade	16	14	6·4	×	0·3
12	Rangeeni, Nov. 1976	Sun	18	14	7·1	×	×
		Shade	18	14	6·7	×	×
13	Rangeeni, Jan. 1977	Sun	20	18	8·5	×	0·3
		Shade	20	18	8·2	×	0·3
14	Rangeeni, Oct. 1977	Sun	22	14	9·3	×	×
		Shade	22	14	9·0	×	×
15	Rangeeni, Nov. 1977	Sun	19	20	7·4	×	0·3
		Shade	19	20	7·1	×	0·3
16	Kusmi, July 1977	Sun	14	20	5·4	×	×
		Shade	14	20	5·0	×	×

(A. K. Ghosh and R. K. Banerjee)

4.1.6 Improvement in dewaxing technique in aqueous medium

Dewaxing of lac in aqueous medium is a very lengthy and tedious process and takes about 48 hr. The process involves two steps, namely, (i) cooling the lac extract to room temperature and removing the scum of lac wax, (ii) filtration

of the solution to separate the remaining wax. In the present study it was desired to shorten the process by combining the two steps into one. This was carried out by taking hot alkaline extract of seedlac and chilling it to 10°C followed by filtration through a drill cloth bag using paper pulp as filtering aid. The wax content of this product was found to be 0·10 to 0·14 per cent. The details are being worked out.

(A. K. Ghosh)

4.2 Rubber-Shellac Combination

4.2.1 Incorporation of modified lacs into rubber

(i) The effect of incorporation of shellac into a blend of 50 parts each of natural and styrene-butadiene rubber (SBR) using easy processing channel (EPC) and high abrasion furnace (HAF) carbon black fillers was studied. The results are brought out in Table 41. It is evident from the data that optimum time cure decreased in presence of both the fillers by the addition of shellac. Modulus was affected slightly but ultimate elongation generally increased with both the fillers. Tensile strength was found to increase up to 10 per cent shellac concentration in case of EPC and 5 per cent shellac concentration in case of HAF and thereafter decreased with both the fillers. Tear resistance, however, showed a decrease with all the concentrations of shellac whereas hardness was improved.

TABLE 41 — EFFECT OF INCORPORATION OF SHELLAC ON THE PROPERTIES OF A BLEND OF 50 PARTS EACH NATURAL AND SBR USING EPC AND HAF FILLERS

(*Base mix*: *NR*, 50; *SBR*, 50; *zinc oxide*, 4; *stearic acid*, 1; *PBN*, 1; *and sulphur*, 2)

Shellac added (per 100 parts blend)	Optimum cure time at 140°C (min)	Modulus at 200% elongation (kg/cm²)	Ultimate elongation (%)	Tensile strength (kg/cm²)	Tear resistance (kg/cm)	Hardness (shore A)
FILLER EPC (70 PARTS) ACCELERATOR MBT (1 PART)						
0	40	16·3	650	61·1	26·4	48
5	20	14·0	750	77·5	25·1	54
10	20	—	800	105·7	22·3	56
15	30	15·7	680	45·4	20·1	61
20	30	14·3	620	36·8	23·3	63
FILLER HAF (40 PARTS) ACCELERATOR CBS (1 PART)						
0	40	42·2	490	133·3	38·1	62
5	20	35·3	600	141·5	39·0	62
10	30	42·4	—	122·1	30·3	66
15	30	29·2	650	111·4	36·9	66
20	30	31·2	600	95·8	30·2	67

(ii) As reported earlier the addition of zinc salt of lac into natural rubber resulted in greater improvements of the mechanical properties as compared to plain shellac when MBT was used as an accelerator. Similar study was made

using CBS as an accelerator. From the data, as given in Table 42, it was observed that addition of 2·5 parts of zinc salt of lac per 100 parts of rubber is optimum to increase the modulus and tensile strength.

TABLE 42 — EFFECT OF INCORPORATION OF Zn-SALT OF LAC ON THE PROPERTIES OF NATURAL RUBBER

(*Base mix*: *NR* 100; *zinc Oxide*, 4; *stearic acid*, 1; *PBN*, 1; *sulphur*, 2·5; *and CBS accelerator* 0·5)

0	30	2·1	840	161·4	26·4	44
2·5	20	2·5	750	165·0	16·0	44
5	20	2·4	800	140·3	20·1	46
10	30	2·6	850	130·2	22·1	47

(B. B. Khanna and Radha Singh)

4.3 Use of Lac in Adhesives

4.3.1 Modified lacs as adhesives

(i) *Modification with phenol formaldehyde resin*

As reported last year, when phenolic resin (PF) was incorporated into shellac, the bond strength decreased for the metal surfaces such as steel, brass and copper. However, the addition of hexamethylene tetramine and lime (5% and 1% on the weight of shellac respectively) improved the bond strength from 0·08 ton/sq inch to 0·24 ton/sq inch over steel surface when PF resin and shellac were taken in equal parts.

(ii) *Modification with epoxy resin*

It was reported earlier that a blend of epoxy resin (epikote 1001) and shellac (1:1) had a bond strength of 0·45 ton/sq. inch on steel surface. This value could be further increased to 0·56 ton/sq. inch when the blend was heated for 30 min at 100°C.

(P. K. Ghosh, M. Islam and R. Prasad)

4.3.2 Heat and water-proof decorative laminates

In order to improve the surface resistance of lac based decorative laminated boards the top decorative papers were impregnated two to three times with modified shellac varnish (Melfolac). The boards were found to have good strength and surface gloss and could be trimmed, sawed or punched without delamination. They passed heat and boiling water resistance test as per IS: 2046-69 and also resisted to mineral acid solutions (2%) and vegetable oils but were slightly affected by dilute alkali solutions.

(P. K. Ghosh and M. Islam)

4.5 Utilization of Waste Mica

Last year, insulating sheets/boards using calcined mica with butylated melamine resin, modified lac and hydrolysed lac were prepared. This year modification of lac was done with formalin and urea. Shellac (100 g) was dissolved in alcohol and modified with formaline (25 g) and urea (9 g) in the

usual way. To the modified varnish, calcined mica (200 g) was added to get a paste. The paste was kneaded, air dried and powdered to 30 mesh. It was then baked at 110°C for 2 hr and moulded into sheets in a hydraulic press, at 135°-140°C under 1 ton/sq inch pressure for 3 min. The moulded composition had an impact strength of 2·20 kg/cm². Though the impact strength was low but thick boards (1/4″) moulded from this composition were quite tough and could withstand drilling, sawing, punching and similar mechanical operations.

(P. K. Ghosh)

(c) RESEARCHES CONTEMPLATED

Washing of sticklac with synthetic detergents.

E. EXTENSION DIVISION

(a) RESEARCHES COMPLETED

Sponsored Research : Scheme on " Coordinated Programme for Evolving Sample Survey Methodology to Estimate the Production of Lac ".

A pilot sample survey for the estimation of lac production was carried out during the year 1975-77 in collaboration with the Indian Agricultural Statistics Research Institute (IASRI), New Delhi. The main objective of the survey was to develop a suitable sampling technique for the estimation of number of lac-hosts, trees under lac cultivation, total production of sticklac and average yield per tree. The field work in connection with the survey was done by the Institute while the technical guidance was provided and analysis of the data was undertaken by the IASRI.

The survey was conducted during *katki* 1975 and *baisakhi* 1975-1976 seasons in Khunti subdivision of Ranchi district (Bihar) which is predominantly a lac growing area. During *katki* 1976 and *baisakhi* 1976-1977 seasons it was extended to Palamau district of Bihar in addition to the area covered in the earlier seasons. Initially, the survey was started with ten enumerators in the first two seasons. They were augmented with additional fifteen enumerators during the subsequent surveys. Each enumerator was allotted four to six villages. They made complete enumeration of lac-hosts and also conducted crop-cutting experiments according to the plan during each survey. The field staff was given intensive training at this Institute in the identification of lac-hosts, lac cultivation practices and method of conducting crop-cutting experiments while IASRI provided the necessary training in the method of data collection, use of list of random numbers for the selection of trees, survey map reading and location of plot. The Directorate of lac Development, Ranchi participated actively in the training programme of the survey.

Data on number of lac-hosts and hosts under lac cultivation in each of the selected villages were collected by the enumerators for two species of lac hosts, viz., *ber* and *palas*. The enumerators visited every plot in the village with the help of a survey map and recorded the information after careful observation of each tree. In each of the selected villages, five *ber* and ten *palas* trees were selected randomly for conducting crop-cutting experiments. These trees were actually harvested by the enumerator with the help of labourers after complete maturity of the crop and the yield of sticklac was recorded by actual weighment.

Measurements like girth of the tree, number of shoots encrusted with lac, total length of encrustation and weight of shoots with lac were also recorded for each of the harvested tree. In addition to this, general information about the selected villages pertaining to lac production was collected.

The following proformae were used for collection of data:

Proforma 1 — General information about the selected village.
Proforma 2 — Information from the households in the selected village about lac cultivation.
Proforma 3 — Enumeration of lac-hosts in the selected village.
Proforma 4 — Selection of cultivated lac-hosts for crop-cutting experiments.
Proforma 5 — Details of information regarding crop-cutting experiments conducted.

In all, lac-hosts in 152 villages of Khunti subdivision and 156 villages of Palamau district were completely enumerated during the course of this survey. Further, 1125 *ber* and 2679 *palas* trees have been harvested in both the regions for observing the yield of sticklac.

The results obtained from this survey indicate that in Khunti Subdivision the estimates of number of *ber* trees under lac cultivation varied from 0·50 to 3·2 lakhs in different seasons while the number of *palas* trees under lac cultivation varied from 0·63 to 3·84 lakhs. The estimates for number of *ber* hosts varied from 3·05 to 4·97 lakhs and that of *palas* from 10·97 to 15·04 lakhs in different surveys. The quantity of sticklac produced was estimated at 1131 to 1265 tonnes in *baisakhi* and 542 tonnes in *katki* season. The average yield of sticklac obtained from a *ber* tree was of the order of 2·64 to 2·72 kg in *baisakhi* and 0·56 to 1·06 kg in *katki* season. The corresponding estimates for a *palas* tree were 1·41 to 1·45 kg in *baisakhi* and 0·65 to 1·27 kg in *katki* season.

Similar estimates have been worked out for Palamau district. The estimates of number of *ber* and *palas* trees under lac cultivation were worked out to be 0·30 and 10·61 lakhs respectively in *katki* 1976. The corresponding estimates of number of *ber* and *palas* trees and the average yield of sticklac per *ber* and *palas* tree were estimated at 3·11 lakhs, 37·88 lakhs, 0·96 kg and 0·92 kg respectively. The estimates of number of *ber* trees under lac cultivation, total number of *ber* trees and the average yield of sticklac per *ber* tree were worked out as 0·82 lakhs, 2·30 lakhs and 3·26 kg in *baisakhi* 1976-77. The corresponding estimates for *palas* were 8·89 lakhs, 30·08 lakhs and 1·49 kg respectively. The estimated total production of sticklac was 1004 tonnes during *katki* 1976 and 1587 tonnes in *baisakhi* 1976-77.

(S. K. Saha, S. D. Sharma, D. V. Subbarao and S. D. Bokil)

(b) RESEARCHES ON HAND

3.2.6 Copolymerization of shellac with vinyl monomers

The emulsion polymerization of shellac with vinyl monomers, such as, ethyl acrylate (EA) and methyl methacrylate (MMA) was studied earlier (A.R.: 1974-76) using potassium permanganate as initiator. During the period under report, graft copolymerization of shellac with acrylamide (AA) and methyl methacrylate

(MMA) was studied in aqueous dioxane at room temperature in presence of ceric ammonium nitrate as initiator. The reaction products were found to be insoluble in common mixed solvents. One of the products (shellac-PMAA) was, however, found soluble in glacial acetic acid.

(P. C. Gupta, P. R. Bhattacharya and S. K. Saha)

5.2 Development of Shellac Bond Powder

It was reported earlier that a shellac bond powder suitable for use in the manufacture of micanite by the solventless process was developed and a sample has been sent to Bharat Heavy Electricals Ltd, Bhopal for evaluation. The report indicated that the bond powder was suitable in all respects except the heat polymerization time and particle size. The bond powder has been further improved by varying proportion of rosin in the composition and a bigger lot is being prepared for sending to BHEL, Bhopal for shop trials.

(S. K. Saha and B. P. Banerjee)

(c) RESEARCHES CONTEMPLATED

Nil

3. EXTENSION

During the period under report the extension activities of the Institute have been carried out by Extension Division and were as follows:

(i) Large scale cultivation of lac at Kundri
(ii) Technical services and development work
(iii) Publicity
(iv) Testing and analysis
(v) Training
(vi) Production and sale of special shellacs in the Production Unit

(i) *Large scale cultivation of lac at Kundri*

Technical guidance was continued to be rendered to the Forest Department, Bihar in running the 421-acre farm having 40,000 *palas* trees at Kundri.

During April 1977 pruning-cum-*ari* harvesting of 15,300 trees was carried out and 7374·6 kg *ari* scraped lac was obtained.

Harvesting of 9190 trees was done in October and 5812 kg broodlac was obtained. Thirty kg broodlac was sold and the remaining was used for inoculating 15,512 trees. A total of 794·5 kg scraped lac was obtained from mature crop.

7·5 tonnes dry sticklac was produced at a cost of Rs 14,000 approximately towards labour charges. Disposal of produce at the rate of Rs 3 per kg fetched a revenue of Rs 22,000 giving a net profit of Rs 8000 approximately.

(ii) *Technical services and development work*

Technical services were as usual rendered to all those interested. These included Government organizations, private institutions and individuals interested in using shellac compositions. Literature on improved method of preparation of seedlac, manufacture of shellac, bleached lac, water-soluble lac, hydrolysed lac, shellac wax, lac-coated urea, French polish, Melfolac, wash primer, sealing wax, gasket shellac, insulating varnishes, insulating tape, multipurpose adhesives, utilization of byproducts of lac industries, etc. were supplied on request. In addition, samples of shellac, water-soluble lac, hydrolysed lac, lac-coated urea, and wash primer were also sent.

A few of the other important activities are mentioned below:

(i) A scheme for establishing seedlac processing unit in rural areas was prepared and sent to the Managing Director, Bihar Panchayati Raj Financial Corporation, Patna. Suitable sites for establishing the said units were also suggested.

(ii) Specific information about the composition of sealing wax was supplied to the CSIR Polytechnology Clinic, Patna and several other parties. The

Forest Department, Bihar was advised regarding a suitable composition of sealing wax to be supplied to the Union Public Service Commission.

(iii) Guidance was provided to a lac manufacturer regarding the hygienic disposal of lac factory waste effluents and their utilization.

(iv) Several entrepreneurs were advised regarding shellac and shellac based Industries.

(v) Literature on "Improved Methods of Lac Cultivation" was supplied to U.P. State Cooperative Marketing Federation and to several other parties.

(vi) A paint manufacturing unit has been supplied all details for the manufacture of shellac wash primer.

(vii) An entrepreneur at Ranchi was provided technical know-how, training and testing facilities in order to enable him to start the manufacture of shellac based baking type insulating varnish.

(viii) Conditions for decolorization of seedlac solution with the help of activated charcoal were worked out at the request of a prominent lac manufacturer and the findings were passed on to him.

(ix) A manufacturer was assisted in choosing the proper quality of shellac for the manufacture of gasket shellac compound. For this purpose different shellac samples sent by the party were evaluated and comments were passed on to him.

(x) A public sector undertaking was assisted in obtaining suitable quality of shellac for use in insulating compositions.

(xi) Assistance in the form of notes, schedules for survey work and personal discussion was rendered to a few individuals engaged in the study of the problems of utilization of shellac on behalf of Government or private agencies.

(xii) A 10 kg sample of water based shellac binder for sand moulds was supplied to Foundry Forge Plant, H.E.C., Ranchi for trials at their shop. The report is awaited. A small sample was also supplied for evaluation to an industrialist who was keenly interested in the product.

(xiii) Samples of shellac and lac dye were sent to several organizations for research purpose.

(xiv) Detailed cost estimates for refining sticklac to seedlac were supplied to the Managing Director, Orissa Small Industries Corporation Ltd., Cuttack and to a few individuals. Schemes on manufacture of bleached lac and Gasket shellac were also supplied to several parties,

(iii) *Publicity*

The Institute participated in the Kisan Mela organized by Ranchi Agricultural College from 18 to 20 Septemer, 1977. The Institute also took part in the National Exhibition of Farm Publication organized by the Directorate of Extension, Ministry of Agriculture and Irrigation, at the Pragati Maidan, New Delhi from 19th to 23rd November, 1977. Besides, samples, charts, photographs and photo-negatives were sent to ICAR in connection with the National Agricultural Fair (Agri. Expo 1977) held at New Delhi from November 13 to December 13, 1977. Publicity brochures, List of Publications, Annual Reports, etc. were also sent to interested parties.

(iv) *Testing and analysis*

One hundred seventy samples of lac and lac products were received during the period under report and in all 402 tests were carried out.

(v) *Training*

Two candidates sponsored by the Industry eompleted a three-month training course on "Industrial Uses of Lac".

Two private candidates were admitted to the course on "Improved Methods of Lac Cultivation" during the Winter session (October 1977 to March 1978).

Besides, a special short-course training on "Improved Methods of Lac Cultivation" of two-month duration was arranged for two nominees of the Scheduled Caste and Tribe Welfare Department, Government of West Bengal and Tribal Development Cooperative Corporation, Government of Orissa.

One candidate sponsored by a Lac Factory was also trained in analysis and testing of lac for one month.

(vi) *Production Unit*

The unit continued to function as usual. The following items were manufactured and sold to interested parties.

Sl No.	Material	Quantity kg	Value Rs
1	DXO grade water-soluble lac	141·00	4230.00
2	DXG grade water-soluble lac	130·00	2678.00
3	ASK grade shellac	102·00	867.00
4	BRF grade bleached lac	19·00	313.50
	Total	392·00	8088.50

4. PAPERS PUBLISHED

Publications and Patents

Publications

The Institute publishes its research findings in leading Scientific and Technical Journals. In addition, a few books and one monograph have also been published. The total number of publications as on 31st December 1977 is as below:

1. Bulletins	
(i) Chemical	147
(ii) Entomological	87
2. Technical notes	30
3. Research notes	
(i) Chemicals	85
(ii) Entomological	52
4. Miscellaneous technical publications	
(i) Physico-chemical	25
(ii) Entomological	48
5. Books and Monographs	14
6. Pamphlets and leaflets	24

A complete list of the Institute's publications together with those of a sister organization, the erstwhile London Shellac Bureau, is supplied free on request.

List of papers published during the year 1977

Sl No.	Authors	Title of paper	Name of Journal
		A. ENTOMOLOGY DIVISION	
1.	Chauhan, N. S.	Gene Expression and Transmission in *Kerria lacca* (Kerr)	*Heredity*, **38** (2), 155-159.
2.	Chauhan, N. S. and Misra, Y. D.	White: a new colour locus in *Kerria lacca* (Kerr)	*Curr. Sci.*, **46** (8), 272-273.
3.	Gokulpure, R. S. and Sen, P.	*Moghania macrophylla* as host record of *Dichocrocis punctiferalis* (Guen.)	*Entomologists' News Letter* **7** (11-12), 48.
4.	Malhotra, C. P.	Studies on thefeeding behaviour of the caterpillars of *Eublemma amabilis* Moore and their importance in its control	*Proc. Symp. Insects and Environment*, Dept. of Zoology. Univ. of Delhi, 42.
5.	Misra, R. C. and Malhotra, C. P.	Role of leaf stalks from *palas* (*Butea monosperma*) in lac production	*J. Bombay nat. Hist. Soc.*, **74** (2), 379-380.
6.	Srivastava, D. C. and Mehra, B. P.	On the abundance of inimical and beneficial insects of the Indian Lac insect *Kerria lacca* (Kerr)	*Proc. Symp. Insects and Environment*, Dept. of Zoology, Univ. of Delhi, 16.

7.	Mehra, B. P. and Sah, B. N.	Bionomics of *Amsacta lactinea* (Cramer) — a pest of *bhalia*	*Indian J. Ent.*, **39** (2), 29-34.

B. AGRONOMY AND PLANT GENETICS DIVISION

1.	Purkayastha, B. K. and Kumar, P.	Note on the propagation of lac-hosts with growth regulators	*Indian J. agric. Sci.*, **47** (2), 108-110.
2.	Sinha, S. S. N. and Kumar, P.	Note on mitotic analysis in four lac-hosts	*Indian J. agric. Sci.*, **47** (7), 360-363

C. CHEMISTRY DIVISION

1.	Goswami, D. N. and Bhattacharya, P. R.	The dielectric behaviour of natural resin, Manila copal	*J. App. Poly. Sci.*, **21**, 2465-74.
2.	Kumar, A.	Kinetics of thermal polymerization of lac Pt. V — Turbidimetric and fractional studies	*J. App. Poly. Sci.*, **21**, 2695-2709.

D. TECHNOLOGY DIVISION

1.	Ghosh, A. K. and Sengupta, S. C.	Reclamation of pure lac dye from lac effluents	*Res. & Ind.*, **22** (4), 219-222.

PATENTS

1.	Mishra, L. C. and Khanna, B. B.	A process for the preparation of superior bleached lac having reduced chlorine and consequently excellent life under heat, flow and keeping quality	Ind. Patent No. 141376 dated 27-8-1977
2.	Singh, R. and Khanna, B. B.	Preparation of rubber compositions having excellent mechanical properties by the incorporation of modified lac	Ind. Patent No. 141510 dated 9-12-1977
3.	Mukherjee, M. and Kumar, S.	Shellac emulsion paints for wall finishing	Ind. Patent No. 141675 dated 22-4-1977

5. SUMMARY

A. ENTOMOLOGY DIVISION

(a) RESEARCHES COMPLETED

1.1.1 Of the three lac cultivation practices tried on *kusum* at Hesal, the standard 4-coupe system has given the best results, followed by the 2-coupe system and villagers' method in the order indicated.

1.3.1 Studies on the relative abundance of the various insects associated with the Indian lac insect, in different crop seasons, have led to the following general conclusions: the number of predators and parasites on *rangeeni* crops is higher than that on *kusmi* crops. Predators are found in higher numbers during the *baisakhi* and the *jethwi*, and parasites during the *katki* and the *aghani* (but remarkably high occurrence of *Tetrastichus purpureus* contributes to the highest number of inimical parasites during the *baisakhi*). *Eublemma amabilis* was the most abundant predator on *rangeeni* insects and *Holcocera pulverea* on *kusmi* insects. Inimical parasites showed two peaks of abundance, one at sexual maturity and another at crop maturity; predators showed a single peak of abundance, at crop maturity. The relative abundance of the associated insects did not vary much with the hosts tried.

1.5.6 The sex-ratio of the progenies raised by mating males, X-irradiated to induce dominant lethals, with virgin females has remained unaffected indicating that paternal genetic effects are expressed in males in *Kerria lacca*.

(b) RESEARCHES ON HAND

1.1.2 Of the seven cultivation practices tried to raise the *jethwi* 1976-*cum-aghani* 1976-77 crop on *bhalia* at Hesal, highest yield was obtained by using 50 g broodlac per bush.

At Amjharia, when the *jethwi* 1976-*cum-aghani* 1976-77 crop was raised on *bhalia* under different cultural practices and brood rates, highest lac yield was obtained with lowest brood rate tried and the cultural práctice T_3 was found to be the best.

1.1.3 Low brood rate with medium fertilizer dose and medium brood rate with medium fertilizer dose, respectively, have given the best yields of *baisakhi* on *galwang* and *katki* on *ber*.

1.1.5 Of the different alternate hosts screened for raising *rangeeni* or *kusmi* crop, monoecious variety of *putri* has sustained the *aghani* 1977-78 crop.

1.2.1 At least ten components have been found to be present in the lipoidal matter extracted from the Indian lac insect. Immature stages of the lac insect have been found to contain approximately 3 per cent (by body weight) crude free amino acids.

1.2.2 The survival period of lac insects could be prolonged up to 61 and 110 days during *katki* and *baisakhi* seasons, respectively, when reared on the improved shred agar substrates soaked with diet D_1.

1.2.3 Administration of chloromycetin to lac larvae through synthetic diet resulted in their mortality in 3 to 4 days suggesting symbiotic nature of micro-organisms present in the body of lac larvae.

1.3.2 With only a few exceptions, an increase in the incidence of the major lepidopterous predators with the increase in brood rate for inoculation was observed on lac crops raised on *kusum*, *palas* and *bhalia*.

1.3.3 Under laboratory conditions, a ratio of 2 males: 1 female and 72 hr time has been found appropriate to induce mating in *Pristomerus sulci*.

1.3.4 Pest control schedule involving the use of endosulfan (Thiodan®) and *Bacillus thuringiensis* (Thuricide®) did not appear to adversely affect the vital and economic attributes of the lac insect.

1.3.5 Investigations were continued at the Regional Field Research Station, Dharamjaigarh (M.P.) to supplement *kusmi* lac production in the region.

1.4.1 Of the five pesticide control schedules tested in the *aghani* 1976-77 crop on *bhalia* at Amjharia, schedule CC has given slightly better results with regard to yield of broodlac and the schedules EE and CE with regard to both broodlac and sticklac.

Spraying of 0·05-0·1% endosulfan and 0·1% cryolite for the suppression of predators in the *baisakhi* 1976-77-*cum-katki* 1977 crop on *palas* at Lota Farm has resulted in better crop yields with 3 sprays compared with 2 sprays of endosulfan at all concentrations. Cryolite did not result in yield improvement.

1.4.2 *Baisakhi* 1976-77-*cum-katki* 1977 crop raised on *palas* at Kundri with crop inoculations at different times varying from 11 October 1976 to 9 November 1976, has been the best from inoculation on 1 November 1976 with Kundri broodlac and lowest from inoculation on 22 October 1976 with Namkum broodlac.

1.4.7 Losses of the various lac crops, raised under natural conditions, due to inimical insects have been estimated to vary between 21·5% and 56·8% when compared to those raised under mechanical protection or chemical protection.

1.5.2 Some of the lines showing superior traits, obtained from crosses of *rangeeni* and *kusmi* strains, are being maintained for further evaluation.

1.5.3 No variant has been recorded in the second and the third generation progenies derived from X-irradiated *jethwi* 1976 male lac insects. The *rangeeni* lac insects appear to be more tolerant to X-irradiation than the *kusmi* insects.

1.5.5 The yolk vacuoles in the eggs of the lac insect gradually blackened when kept in 2 per cent osmic acid indicating the presence of fatty yolk in them.

1.5.8 Four stocks each of the *rangeeni* and *kusmi* strains from different regions of the country are being maintained.

Operational Research Project

The demonstrations of lac cultivation conducted in the area have shown that sticklac yield per *ber* tree can be increased to 2·7 times by the improved method of lac cultivation.

B. AGRONOMY AND PLANT GENETICS DIVISION

(a) RESEARCHES COMPLETED

Nil

(b) RESEARCHES ON HAND

2.1.1 Out of forty varieties/cultivars of *arhar* raised, the "Assam" was found the best for lac yield while ICRISAT Nos. 4725, 3682 and 1986 for grain yield.

2.1.2 Of the different systems of planting and fertilizers on the growth of *bhalia* plants, the equitriangular system of planting with 1·25 m× 1·25 m followed by the application of phosphate fertilizers gave better results with respect to broodlac yield.

2.3.1 The suitability of the factors, namely, spacing, coppicing heights and seasons of coppicing for the training of rain tree into bushes for lac cultivation on plantation basis was tested. The plants coppiced at a height of 15 cm in March showed better growth response compared to other treatments.

2.3.2 Of the two plant growth regulators, namely, GA and NAA used for the study, NAA at 80 ppm was found superior for seed treatment in respect of shoot length and yield of lac.

To reduce the gestation period of *M. macrophylla* and *A. lucida* for lac cultivation, the foliar spray of GA was tried at different concentrations. The best result was obtained at 40 ppm in both the host plants.

2.4.1 (a) The germination percentage of X-ray irradiated *bhalia* seeds decreased with the increase in doses of irradiation.

(b) The lac crop on *bhalia* plants raised earlier from gamma irradiated seeds is under progress.

2.4.2 In course of further study on floral biology, the diameter of pollens and period of anthesis in *M. macrophylla* and *M. chappar* were recorded. In addition, the pollen viability test was carried out.

2.4.3 (a) *Bhalia* plants raised from seeds of 27 (high) and 9 (low) lac yielders have shown satisfactory growth.

(b) The plants raised earlier for selection studies were coppiced and inoculated with lac for raising the *aghani* crop.

C. CHEMISTRY DIVISION

(a) RESEARCHES COMPLETED

3.2.3 Hydrolysed lac has been modified with epichlorohydrin and epoxy resin of different molecular weights. The resultant products on curing wiht toluene di-isocyanate at room temperature give films which are glossy and resistant to water, dilute acids and alkalies.

(b) RESEARCHES ON HAND

3.1.1 (i) *Threo*-9,10-dihydroxy palmitic acid (m.p. 85-87°C) was synthesized from *threo*-aleuritic acid and converted to its *erythro* isomer (m.p. 119-121°C) and vice versa.

(ii) 7-Hydroxy tetra decanoic acid (m.p. 51-53°C) was synthesized by condensing heptyl magnesium bromide with cycloheptamone and adopting the usual procedure.

(iii) Aleuritic and butolic acids have been resolved into (+) and (−) isomers using cinchonine.

3.1.2 (i) The acid (m.p. 83-84°C) obtained from the hydrolysis of the ester (m.p. 93-94°C) was methylated. IR spectra of the acid and ester showed absorption at 1710^{-1} cm and 1750^{-1} cm respectively.

(ii) One pure component having R_f value 0·76 was isolated from alcohol soluble fraction C of lac wax.

(iii) Whole lac wax was fractionated quantitatively by alcohol, acetone and petroleum ether (b.p. 60-80°C) into different fractions and their acid values were determined.

3.1.4 The new terpenic acid, separated from hard resin fraction (B-3), formed 2:4-dinitrophenyl hydrazone derivative thus confirming its aldehydic nature. By end group analysis, the molecular weight of the new acid was found to be 255. A method has been developed to prepare the acid directly from stick lac.

The estimation of aleuritic and jalaric acids in their synthetic mixture (1 : 1, w/w) confirms that in hard resin, the ratio of aleuritic and jalaric acids is nearly 1 : 1 (w/w).

3.1.5 The synthetic resins, such as, phenol-formaldehyde, urea-formaldehyde and melamine-formaldehyde have not indicated the presence of any aldehydic component as estimated by sodium sulphite method in their water soluble portion, obtained by partial hydrolysis. Lac resin contains nearly 36 per cent of aldehydic acids (jalaric/*lacci*-jalaric) as estimated by spectronic absorption method.

3.2.2 The cation exchange resin developed from shellac was got evaluated at Central Salt and Marine Chemical Research Institute, Bhavnagar and certain drawbacks reported, such as, slow rate of exchange, colour throw and low breakthrough capacity have now been overcome.

3.2.4 In order to prepare unsaturated derivative, aleuritic acid was condensed with allyl alcohol/crotonic acid/cinnamic acid. The products have been characterized for their chemical constants.

3.2.7 The vicinal hydroxyls of 9,10-dihydroxy 1,16-dicarboxylic acid are the points where crosslinking is most likely to occur during the reaction with ethylene glycol. Attempts were made to replace them with halogen or acetate groups and also to create unsaturation in 9,10-dihydroxy 1,16-dicarboxylic acid. However, these were not successful.

3.2.8 Shellac based polyesters were prepared using glycols like ethylene glycol and diethylene glycol and dicarboxylic acids like adipic, terephthalic, phthalic or maleic anhydride. The polyesters will now be reacted with diisocyanates to yield shellac polyurethanes.

3.2.9 Dewaxed lac, *kusmi* lac and hydrolysed lac were reacted up to pregelation stage with sulphur by dry fusion at 150°C. It was found that 1·8, 3·5 and 3·7 per

cent sulphur had gone into combination. The amounts increased to 3·2, 2·8 and 4·2 per cent when an accelerator (MBT) was used. An examination of sulphur modified products indicated a drop in acid, hydroxyl and iodine values.

3.3.3 The preparation of lac-double boiled linseed oil varnish in bigger lots (1·5 litres) was studied without experiencing any difficulty. The varnish so obtained gave more or less similar performance as obtained on laboratory scale. It gave high BDS (3 kV/mil) and showed many other desirable properties of a baking type insulating varnish.

3.3.6 A composition based on shellac-linseed oil-toluene diisocyanate showed only slight deterioration even after one and a half year immersion in gobar-slurry under laboratory conditions indicating possibility of its use on the gas holders of gobar-gas plants.

3.5 Further studies have resulted in solid propellants (shellac based rocket fuel) which were smooth, compact and possessed improved flexibility but gave a slightly smoky flame, and those which were flexible and comparatively softer but burnt with a luminous flame.

3.4.1 In order to develop a mechanical method for coating solid pesticides/ insecticides, a coating apparatus based on fluidized-bed technique is being designed.

3.4.2 Systematic studies on lac hydrosols have been undertaken. Aqueous solutions of *bhatta* and DL shellac and their corresponding hydrosols have been prepared by adopting dialysis and pouring techniques and their physico-chemical properties have been studied.

3.7.1 The dielectric relaxation data of shellac and its constituents have been analysed by the Cole-Cole method at temperatures between 10° and 110°C in the frequency range 50 Hz-500 kHz. Both shellac and hard fraction exhibited three relaxation processes between 30° and 60°C, two processes at 70°C and one at 80°C and above. On the other hand, soft fraction showed two processes for temperatures between 10° to 40°C and one process between 70° and 90°C.

Both the glass-transition and melting temperatures of hard fraction were greater by 10°C and the corresponding temperatures for soft fraction were about 30°C lower than those of shellac. The marked changes in the different dielectric parameters observed for shellac, hard and soft fractions above their melting temperatures suggest conformational changes of the resin molecules. The functional groups present in hard and soft resins appeared to be responsible for the dielectric properties exhibited by shellac below its glass-transition and melting temperature respectively.

3.7.2 The addition of tricresyl phosphate (20%) to shellac varnish brings about two-fold increase in the breakdown strength of the varnish (air dried). This is also accompanied by a marked improvement in the flexibility. Humidity decreases the breakdown strength.

D. TECHNOLOGY DIVISION

(a) RESEARCHES COMPLETED

4.1.2 *Correlation of the properties of shellac and seedlac*

In trade, different qualities of seedlacs are mixed in different proportions to obtain shellac of requisite standard. However, this process of mixing is highly

empirical. Systematic studies have been made to correlate the properties (e.g. life, flow and colour) of seedlac to shellac made therefrom.

Seedlacs of different qualities as well as their mixtures (in different ratios) were converted into shellac by *bhātta* process. The properties of the seedlacs, their mixtures and the resulting shellacs were studied. It was found that life, flow and colour of the resulting shellacs were dependent on the respective values of these properties of the parent seedlacs and were proportional to the ratio in which the parent seedlacs or shellacs were mixed.

(b) RESEARCHES ON HAND

4.1.1 A simple process for the preparation of shellac and dewaxed lac in aqueous medium up to semi-pilot scale has been studied.

4.1.5 It was observed that the seedlac which was dried in the sun had red colour higher by 0·3 to 1·1 unit, common range being 0·3-0·5, as compared to the seedlac dried in shade.

4.1.6 A quick method for dewaxing of lac in aqueous medium is being worked out. The wax content of the product was found between 0·10 and 1·14 per cent.

4.2.1 The effect of incorporation of shellac into a blend of natural rubber and styrene-butadiene rubber in presence of fillers (EPC and HAF) was studied. Tensile strength was found to increase in both the cases as compared to the control. Some of the other properties also showed improvement.

4.3.1 (i) When shellac was modified with phenolic resin in presence of hexamethylene tetramine and lime, the bond strength was improved.
(ii) When shellac and epoxy resin (1 : 1) were heated together the bond strength was improved.

4.3.2 Decorative laminates prepared from melfolac were found to have good gloss, heat and water resistance but lacked alkali resistance.

4.5 Shellac modified with formaline and urea was mixed with the calcined mica and the resulting product was moulded in a hydraulic press. The boards prepared from this composition were quite tough.

E. EXTENSION DIVISION

(a) RESEARCHES COMPLETED

SPONSORED RESEARCH

A pilot sample survey for the estimation of lac production was carried out in collaboration with the Indian Agricultural Statistics Research Institute, New Delhi. During the course of the survey lac hosts in 152 villages of Khunti subdivision and 156 villages of Palamau district were completely enumerated. Estimates have been worked out separately for each region seasonwise and hostwise.

(b) RESEARCHES ON HAND

3.2.6 Graft polymerization of shellac with acrylamide and methyl methacrylate in aqueous dioxane has been studied. The reaction products were found to be insoluble in common solvents.

5.2 The shellac bond powder developed earlier was further improved by adjusting the rosin content in order to increase the heat polymerization time.

6. METEOROLOGICAL REPORT FOR THE YEAR 1977

The average meteorological data for each month were as follows:

Month	Mean barometric pressure (mm)	Mean maximum temp. (°C)	Mean minimum temp. (°C)	Mean dry bulb temp. (°C)	Mean wet bulb temp. (°C)	Mean humidity (%)	Mean sunshine (hr/day)	Total rainfall (mm)	Highest maximum temp. (°C)	Lowest minimum temp. (°C)
January	709·2	24·9	7·8	19·2	13·4	50·3	7·51	23·0	29·0	3·0
February	708·8	27·2	10·1	22·4	14·3	39·0	7·76	14·1	33·0	4·0
March	707·0	34·4	15·9	29·7	18·0	29·7	8·69	12·3	37·5	12·0
April	703·0	35·8	20·4	30·9	20·6	40·0	7·46	80·4	39·5	16·0
May	701·6	33·9	20·2	29·5	22·7	56·2	6·80	127·5	39·6	15·5
June	698·4	33·0	22·1	29·2	23·8	63·5	4·76	254·1	42·8	20·0
July	697·6	29·2	22·0	26·4	24·0	87·3	3·13	521·8	33·0	20·5
August	699·6	30·6	21·7	26·4	24·7	87·0	3·99	330·3	32·0	20·4
September	702·1	30·0	20·7	27·0	24·0	78·2	5·88	171·6	33·0	19·0
October	707·3	30·6	17·0	27·2	21·7	61·0	—	46·4	33·0	13·3
November	707·8	28·0	15·0	22·8	19·0	70·3	6·08	29·8	32·0	11·1
December	710·2	24·0	8·4	19·5	14·5	58·3	7·11	25·7	28·0	5·0

*Sun recording papers were not available, therefore data could not be taken. The highest maximum temperature recorded was 42·8°C on 5th June and lowest minimum temperature 3·0°C on 2nd January. The total rainfall during the year was 1637 mm, of which the monsoon (June to Sept.) rainfall was 1277·8 mm. The rainfall during the year was lower than that of 1976 (1782·5 mm). There was a mild hailstorm on 26th March.

LIST OF PERSONNEL

Sl No.	Name of the post	Staff in position as on 31-12-77
1.	Director	Dr. T. P. S. Teotia
	Division of Entomology	
2.	Head, Division of Entomology	Vacant
3.	Scientist S-3 (Agricultural Entomology)	1. Sri N. S. Chauhan
4.	Scientist S-2 (do)	1. Dr. B. P. Mehra
		2. Dr. C. P. Malhotra
		3. Sri A. H. Naqvi
5.	Scientist S-1 (Agri. Ento.)	1. Sri R. S. Gokulpure
		2. Sri R. C. Mishra
		3. Sri S. G. Chaudhary
		4. Sri A. K. Sen
		5. Sri B. N. Sah
		6. Dr. D. C. Srivastava
6.	Scientist-S (Agri. Ento.)	1. Sri Y. D. Mishra
		2. Sri M. L. Bhagat
		3. Sri S. K. Jaipuriar
		4. Sri Jawahir Lal.
		5. Sri P. Sen
7.	Senior Technical Assistant (T-4)	1. Sri J. M. Dasgupta
		2. Sri R. C. Maurya
8.	Technical Assistant (T-II-3)	Sri M. K. Chowdhury
9.	Senior Artist (T-4)	Sri R. L. Singh
10.	Jr. Artist (T-II-3)	Sri P. Das
11.	Laboratory Technician T-2	1. Sri B. B. Chakravorty
		2. Sri G. M. Borkar
		3. Sri Ajmer Hussain
12.	Field Technician T-2	1. Sri R. S. Maliya
		2. Sri K. C. Jain
		3. Sri H. R. Munda
		4. Sri S. N. Sharma
		5. Sri S. S. Prasad
		6. Sri R. D. Pathak
		7. Sri R. N. Vaidya
13.	Field Technician (T-1)	1. Sri H. N. Shukla
		2. Sri Jiwan Lal
14.	Insect Collection Tender (T-1)	Sri Ram Lochan Ram
15.	Field Plantation and store Asstt. (T-1)	Sri Munna Lal Ravidas
16.	Laboratory Technician (T-1)	1. Sri S. K. Chatterjee
		2. Miss Santoshi Minz
		3. Sri Bhola Ram
		4. Sri Ghanshyam Das
17.	Research Scholar	1. Sri R. B. Dubey
		2. Sri Chabban Ram
		3. Sri D. N. Putatunda
		4. Sri S. N. Mukherjee
		5. Sri D. Chakraborty
		6. Sri A. Bhattacharya

Agronomy and Plant Genetics Division

1.	Agronomist	Vacant
2.	Jr. Arboriculturist	Sri B. K. Purkayastha
3.	Scientist S-1 (Plant Genetics)	Dr. P. Kumar
4.	Scientist S-1 (Plant Breeding)	Sri S. C. Srivastava
5.	Scientist 'S'	1. Dr. Moti Ram 2. Sri B. P. Singh
6.	Laboratory Technician (T-2)	Sri D. D. Prasad
7.	Field Technician (T-1)	Sri Jagarnath Oraon

Chemistry Division

1.	Head, Division of Chemistry	Dr. B. B. Khanna
2.	Scientist (S-3)	Sri S. Kumar
3.	Scientist (S-1)	1. Dr. A. Kumar 2. Sri A. K. Das Gupta 3. Sri D. N. Goswami 4. Dr. B. C. Srivastava
4.	Scientist 'S'	1. Sri A. Rahman 2. Sri N. Prasad 3. Sri R. N. Majee 4. Sri R. N. Das 5. Sri K. M. Prasad 6. Sri M. Mukherjee
5.	Technical Assistant T-II-3	1. Sri N. K. Dey
6.	Laboratory Technician (T-2)	1. Sri U. Sahay 2. Sri B. P. Keshri
7.	Glass blower	Vacant
8.	Laboratory Technician (T-1)	1. P. B. Sen 2. Sri G. Misra 3. Sri R. P. Sahu
9.	Research Scholar	1. Sri N. P. Verma 2. Sri Ashok Kumar 3. Sri M. K. Mishra 4. Sri Basu Deva Singh 5. Sri K. N. Rao 6. Sri B. C. Ruhidas 7. Sri K. R. Karunamay

Technology Division

1.	Technologist (S-2)	Vacant
2.	Jr. Technologist S-1 (Processing)	Sri A. K. Ghosh
3.	Jr. Technologist S-1 (Factory)	Sri P. K. Ghosh
4.	Scientist S	1. Sri R. K. Banerjee 2. Sri Radha Singh
5.	Sr. Tech. Asstt. (T-4)	1. Sri M. Islam 2. Sri B. P. Banerjee 3. Sri R. Prasad
6.	Laboratory Technician (T-2)	1. Sri N. Minz 2. Sri M. K. Singh
7.	Laboratory Technician (T-1)	Sri Tulsi Ram

Extension Division

1.	Scientist S-2 (Shellac utilization)	Dr. S. K. Saha
2.	Scientist S-1 (Shellac utilization)	Dr. P. C. Gupta
3.	Assistant Scientist (Processing) S-1	Dr. A. Pandey
4.	Senior Analyst (T-5)	Sri L. C. Mishra

5.	Technical Assistant (T-II-3)	1. Sri K. M. Sinha 2. Sri Deepak Ghosh
6.	Laboratory Technician (T-2)	1. Sri D. Runda 2. Sri B. P. Ghosh
7.	Museum Assistant (T-2)	Vacant

Administrative Section

1.	Sr. Administration Officer	Sri K. K. Mustaufi
2.	Assitt. Administrative Officer	Sri S. K. Sircar
3.	Superintendent	1. Sri S. N. Sharma 2. Sri S. N. Prasad
4.	Assistants	1. Sri R. K. Singh 2. Sri P. K. Chaudhary 3. Sri D. P. Sengupta 4. Sri H. S. Munda 5. Sri R. P. Singh 6. Sri Musafir Singh 7. Sri Enamul Haque
5.	Senior Stenographer	Sri R. Rabidas
6.	Senior Clerk	1. Sri D. N. Mahto 2. Mohd. Samiullah 3. Sri A. K. Chowdhary 4. Sri Elias Tirkey 5. Sri A. Haque 6. Sri S. K. P. Keshri 7. Sri R. B. Singh 8. Smt. Sati Guha 9. Sri K. N. Sinha 10. Sri K. D. Pandey 11. Sri S. Ram 12. Sri N. Mahto 13. Sri D. Ram
7.	Junior Stenographer	1. Sri Sant Kumar 2. Sri J. Singh 3. Sri A. K. Sinha
8.	Pharmacist	Sri Chandreswar Pandey
9.	Jr. Clerk	1. Sri K. L. Chowdhary 2. Sri R. K. Upadhaya 3. Sri Budhan Ram 4. Sri A. K. Lal 5. Sri Mohd. Mubarak 6. Sri N. Topno 7. Sri V. Ram 8. Sri E. Gari 9. Sri J. P. Srivastava

Audit and Accounts Section

1.	Assistant Accounts Officer	Sri K. K. Bose

Project File and Technical Cell

1.	Jr. Technical Officer, T-6	Sri S. K. M. Tripathi
2.	Sr. Technical Assistant, T-4	Vacant

Library

1.	Sr. Library Assistant (T-4)	Sri R. P. Tiwari

Maintenance and Workshop Unit

1.	Chief Mechanic (T-II-3)	Sri K. N. Sinha
2.	Assistant Mechanic (T-2)	Sri S. K. Bhaduri

3.	Instrument Maker (T-2)	Sri M. Kujur
4.	Turner (T-1)	Sri A. S. Manoranjan
5.	Driver for Vehicle (T-1)	1. Sri J. Ram 2. Sri Bandhan Runda

Institute Plantation

1.	Farm Superintendent	Vacant
2.	Jr. Field Asstt. (T-2)	1. Sri G. Lakra 2. Sri Md. Ali Ansari
3.	Labour Supervisor	Sri Mohar Sahu
4.	Tractor Driver	Sri Markus Surin

Mixed Plantation Scheme at Chandwa

1.	Field Technician (T-2)	Sri R. C. Singh

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