INDIAN LAC RESEARCH INSTITUTE
NAMKUM, RANCHI, BIHAR, INDIA

Annual Report
1970

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
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CONTENTS

1. DIRECTOR'S INTRODUCTION

A brief historical introduction

The Indian Lac Research Institute came into existence as a result of the recommendation of an enquiry committee, comprising Mr. H. A. F. Lindsay and Mr. C. M. Harlow, appointed early in 1920 by the then Government of India to enquire into the conditions of the Indian Lac Trade and suggest measures for its all round improvement. The report of this Committee was published in 1921 in which they observed, *inter alia*, that the two major ills from which lac trade was then suffering, namely, liability to violent price fluctuations and adulteration in times of short supply, could be cured only by improved outturn. For this, they suggested that recourse should be taken to *intensive* cultivation by scientifically tested methods, rather than to *extensive* cultivation. In order to implement this suggestion, members engaged in the lac trade at the time constituted themselves into a private registered body under the name of the Indian Lac Association for Research. This Association set up the Indian Lac Research Institute in 1925.

In 1930, on the recommendation of the Royal Commission for Agriculture (1927), the Indian Lac Cess Act was passed by the Central Legislature. Under this Act, the Government of India constituted the Indian Lac Cess Committee which took over the Institute from "Lac Association" in 1931. The Committee maintained the Institute till 31st March, 1966. With the abolition of the Committee on this day, the Institute was taken over by the Indian Council of Agricultural Research with effect from 1st April, 1966. The Institute is now functioning under this Council.

The Institute is situated at Namkum about nine kilometres east of Ranchi. The laboratories of the Institute consist of three buildings housing the Chemistry Laboratory, the Entomology Laboratory and the Experimental Factory. The Institute Library adjoins the Entomology building. The Administrative Section and Museum are housed in another block. The waterworks, workshop, gas plant etc. are located in small constructions between the Chemistry and Entomology Laboratories. The Audit and Accounts Section and a unit of the Administrative Section are temporarily accommodated in two small rooms adjoining the workshop previously occupied by the Chemistry Division. There is a dearth of accommodation.

Apart from these, the Institute also has an adjoining plot of over 35 hectares for use as an experimental plantation. The total estate of the Institute at Namkum including the plantation covers an area of about 49 hectares. For outstation experiments, areas/trees have been taken on long term lease.

The Institute is headed by the Director who also functions as Head of the Chemistry Division. The Head of the Division of Entomology is the Entomologist.

Objectives

The main objective of the Institute is to carry on research towards effecting improvements in the cultivation, processing, standardization and modification of lac through scientific research, so as to intensify cultivation and extend utilization. In addition, the Institute is also to carry on publicity and maintain liaison with and provide technical service to the indigenous industries towards improving the quality of their products and increased utilization of lac.

Organizational structure

Present structure of the Institute is indicated in the following plan:

Director

Entomology Division (This includes the Training Section also)	Chemistry Division (This includes the Utilization Section also)	Administrative Section	Audit and Accounts Section	Mechanical Section	Library

Achievements

Among the major achievements during the year in the field of lac cultivation and entomology particular mention may be made of the findings that (i) *palas* broodlac is preferable for *Baisakhi* inoculation on *palas* hosts and *ber* for *Katki* on *ber* hosts, (ii) *ber* broodlac can be safely harvested a week earlier than the normal time of larval emergence without any appreciable loss in brood value, (iii) the successful propagation of *bhalia* from shoot cuttings using plant growth hormones, (iv) the male lac insect has a unique chromosomal situation, which though somatically a diploid, breeds as a haploid transmitting only the maternal genome through the sperm and (v) the lac insects have an unusual mating system; the females are usually mated to a number of males.

Other important findings are the evidence of the genetic basis of differential host preference by *Rangeeni* and *Kusmi* strains of lac insects and the alkalinity of the digestive tract of the predatory larvae.

In the field of lac technology the new process for the production of shellac directly from sticklac was standardized and scaled to semi-pilot experiments. All varieties of shellac, such as dewaxed, dewaxed and decolourised, and decolourised waxy lac may be produced by this method eliminating one intermediate step thereby resulting in a 20-25 percent increase in yield. Another important development is the preparation of bleached lac of low colour index (0·31) and chlorine content (0·6%) which was obtained by bleaching lac with sodium hypochlorite and hydrogen peroxide without impairing its properties.

In the field of utilization, an alternate solvent (90% isopropyl alcohol) was found out for French polishing of furniture in place of the conventional solvent, methylated spirit. Another notable finding is the superiority of lac/melamine or urea resin composition over parent lac for use as an insulating varnish or moulded insulator in electrical industry.

Library

The number of books and bound volumes of journals accessioned during the year was 563. This brought the total number of books and bound volumes of journals in the library as on 31st December, 1970 to 13970. One hundred and eight periodicals were subscribed for 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.

Honours and awards

Shri S. C. Agarwal, Research Assistant (Chemistry) was awarded a Ph.D. degree of Aligarh Muslim University for his work at this Institute on "Studies on the constitution of lac". Shri N. Majumdar, Senior Research Assistant (Entomology) was awarded Senior Fellowship of Indian Council of Agricultural Research for his Ph.D. studies at Calcutta University. Shri C. P. Malhotra, Scientific Officer (Field Station) who availed a Senior Fellowship of Indian Council of Agricultural Research for his Ph.D. studies at Indian Agricultural Research Institute, New Delhi, returned and joined the Institute on 2nd March, 1970 after completing his research work.

Visitors

This 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. This included among others:

(i) Dr. C. Krishna Rao, Animal Husbandry Commissioner, Government of India.

(ii) Dr. G. K. Manna, D.Sc., Dean of Faculty of Science, Kalyani University, West Bengal.

(iii) Prof. S. C. Mandal, Director of Agricultural Research, Government of Bihar, Patna.

(iv) Mr. William B. Cox of American Embassy, New Delhi.

(v) Dr. Ted S. Brooks, USAID Expert on Plant Protection.

Besides, a delegation of three Sericulturists from the U.S.S.R. was another distinguished team who paid a visit to the Institute during the year. The delegation comprised:

(i) Dr. S. D. Lavrentiev, Head of Sericultures Department, Central Board of Cotton Breeding and Fibre Plants, USSR, Ministry of Agriculture.

(ii) Dr. R. A. Guseinov, Head of the Breeding Division, Azerbaijan Research Institute of Sericulture.

(iii) Dr. E. H. Jajiv, Head of the Central Board of Sericulture, Uzbekistan, Ministry of Agriculture.

Research collaboration with other Institutions

Apart from work within its own premises, the Institute has always sought to take advantage of technical know-how and facilities available in other Institutions also for the furtherance of its objectives. A Research Project is being implemented since 1960 under which the constitution of lac is being studied simultaneously (i) at the Chemistry Laboratory of the Delhi University under the guidance of Prof. T. R. Seshadri, F.R.S. and (ii) at the National Chemical Laboratory, Poona, under the guidance of Dr. Sukh Dev. In addition, study is in progress on the development of shellac based leather finishes at the Central Leather Research Institute, Madras under a separate scheme.

A scheme of co-operative research has been taken up with the National Metallurgical Laboratory, Jamshedpur, for investigating the possibilities of shellac as binder for sand moulds and cores of Foundries.

The Institute continued to avail of the testing facilities kindly provided by the Indian Institute of Technology, Kharagpur, for our work on shellac/rubber combination. The Indian Agricultural Research Institute, New Delhi also helped in the irradiation of seeds and lac samples in their laboratories by their own staff for mutation studies.

Facilities were also sought for and obtained from the Agricultural Research Institute, Kanke, Ranchi, and Jute Agricultural Research Institute, Barrackpur, Calcutta for agronomical studies on maize and wheat, and jute respectively with coated urea fertilizer.

The Institute is represented in the Lac Development Council of the Ministry of Food and Agriculture, Government of India, in the Shellac Export Promotion Council and various Technical Committees of the Indian Standards Institution.

Research collaboration at International level

The Institute has also taken advantage of International Technical Co-operative Schemes to provide specialized knowledge to its employees. Six scientists of the Institute have so far been provided advanced training in various disciplines under the Colombo Plan, five in the United Kingdom and one in Canada.

Advisory Services

The Institute provides technical assistance to all those interested in the cultivation, processing, grading and utilization of lac (see page 58).

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

Four trainees from Lac Development Department, Department of Industries (West Bengal) and two private candidates completed the training during the October 1969-March 1970 session and during the following session April-September 1970 five candidates, four from the Department of Agriculture, Uttar Pradesh, and one from the Forest Department, Mysore successfully completed

the six month's training course in improved methods of lac cultivation. Two private candidates, one from Bilaspur, Madhya Pradesh and other from Madras, Tamilnadu completed the six month's training in industrial uses of lac.

Four trainees from Khadi and Village Industries Commission, Bombay, one trainee from Community Project, Ranchi and one private candidate completed the training in a condensed course of three months in industrial uses of lac during the period 15th October 1970 to 13th January 1971.

For the benefit of the trade and industry, the Institute also maintains Regional Analytical Laboratory in the major lac processing centres of the country. During the period under report, two laboratories were functioning, one at Namkum (Ranchi) and the other at Balrampur (Purulia Distt.), West Bengal. The latter, however, was closed down with effect from 1st March 1970.

Finance

Since its inception, the Institute was being financed through a cess levied on all exports of lac. Since 1962-63, however, some grants were also received from the Govt. of India as the income from the cess was found inadequate. Since the takeover with effect from 1st April, 1966, the Institute is being wholly financed by the ICAR.

The final budget estimates of the Institute for 1970-71 amounted to Rs. 12,39,500. The actual expenditure during the same period was, however, Rs. 12,06,632.25 only.

2. PROGRESS OF RESEARCH

(A) ENTOMOLOGY DIVISION

(a) RESEARCHES COMPLETED

Lac Cultivation Studies

1. Studies on the relative merits of *ber* and *palas* broodlacs for use on *ber* and *palas* hosts

This study was in progress since November 1967 with a set of 5 trees each of *palas* and *ber* appropriately pruned and inoculated with *ber* broodlac and a second similar set with *palas* broodlac. The crop data for three years are set out in Table 1.

It will be seen from the table that in the *Baisakhi* season *palas* gives higher yields than *ber* and the yield is higher with the use of *palas* broodlac than *ber* broodlac on both *palas* and *ber*.

In the *Katki* season, however, *ber* is a better host than *palas* and the *ber* broodlac is preferable for both *palas* and *ber*.

2. Studies to ascertain the most appropriate time for harvesting *ber* broodlac for crop inoculation

This study was taken up in 1967 with a view to ascertain how early, prior to larval emergence, *ber* broodlac can be harvested and will still be suitable for raising the subsequent crop. Five kg of broodlac was harvested 3, 2 and 1 week before and at the time of larval emergence and progenies from each lot were reared separately on 5 trees.

It was found that the larval emergence takes place from broodlac harvested upto two weeks earlier than the time of larval emergence, but crops were satisfactory with broodlacs harvested upto a week earlier (*vide* Table 2). The crop was best with the broodlac harvested at the time of larval emergence (treatment D). However, a reasonably good crop was also obtained with the broodlac harvested a week earlier.

Thus, if early harvesting is necessitated for purposes of despatch to distant places or when large areas are desired to be inoculated, the broodlac can be safely harvested a week earlier than the time of larval emergence.

(b) RESEARCHES IN HAND

Lac cultivation studies

1. Determination of optimum broodlac repuirement for maximizing *ari* yield on *palas* in hot areas

Previous studies had indicated that the maximum brood rate tried i.e. 0·5 kg per tree, gave the highest yield (*A. Rep.* 1968). In order, therefore,

TABLE 1 — STUDIES ON THE RELATIVE MERITS OF *ber* AND *palas* BROODLACS

Crop	Host	Brood used	Brood	Number of trees	Ratio of brood yield used to brood (lac sticks)	Ratio of brood yield used to brood (lac sticklac)	Ratio of brood used to total yield (sticklac)	Yield in kg per tree (sticklac)
Baisakhi 1967-68	*palas*	*palas*	1 kg	5	1 : 3·10	1 : 3·51	1 : 3·51	0·562
	palas	*ber*	do	do	1 : 4·47	1 : 5·73	1 : 5·23	0·688
	ber	*palas*	do	do	1 : 0	1 : 0	1 : 2·63	0·368
	ber	*ber*	do	do	1 : 0	1 : 0	1 : 5·33	0·533
Baisakhi 1968-69	*palas*	*palas*	do	do	1 : 3·38	1 : 2·86	1 : 3·41	0·833
	palas	*ber*	do	do	1 : 3·08	1 : 2·38	1 : 2·77	0·700
	ber	*palas*	do	do	1 : 0·60	1 : 0·38	1 : 2·01	0·476
	ber	*ber*	do	do	1 : 0	1 : 0	1 : 1·77	0·410
Baisakhi 1969-70	*palas*	*palas*	do	do	1 : 4·32	1 : 3·98	1 : 5·31	1·280
	palas	*ber*	do	do	1 : 2·78	1 : 3·37	1 : 4·40	1·100
	ber	*palas*	do	do	1 : 0·34	1 : 0·31	1 : 3·20	0·730
	ber	*ber*	do	do	1 : 0·30	1 : 0·33	1 : 2·61	0·640
Katki 1968	*palas*	*palas*	do	do	1 : 1·36	1 : 1·19	1 : 1·11	0·215
	palas	*ber*	do	do	1 : 3·24	1 : 1·82	1 : 1·82	0·475
	ber	*palas*	do	do	1 : 1·88	1 : 1·04	1 : 1·92	0·480
	ber	*ber*	do	do	1 : 2·60	1 : 2·31	1 : 2·31	0·690
Katki 1969	*palas*	*palas*	do	do	1 : 2·34	1 : 2·02	1 : 2·91	0·648
	palas	*ber*	do	do	1 : 2·61	1 : 2·00	1 : 2·77	0·700
	ber	*palas*	do	do	1 : 2·91	1 : 2·70	1 : 3·03	0·741
	ber	*ber*	do	do	1 : 3·60	1 : 2·91	1 : 3·50	0·858
Katki 1970	*palas*	*palas*	do	do	1 : 2·52	1 : 2·85	1 : 4·51	1·092
	palas	*ber*	do	do	1 : 3·04	1 : 3·40	1 : 4·60	0·992
	ber	*palas*	do	do	1 : 3·70	1 : 3·68	1 : 5·41	1·340
	ber	*ber*	do	do	1 : 4·96	1 : 4·62	1 : 6·03	1·460

TABLE 2 — STUDIES TO ASCERTAIN MOST APPROPRIATE TIME FOR HARVESTING *ber* BROODLAC FOR CROP INOCULATIONS

Crop	Host	Brood used	Brood rate	Treatment*	Number of trees	Yield			Remarks
						Ratio of brood used to brood yield (lac stick)	Ratio of brood used to total yield (sticklac)	Yield of broodlac per kg per tree (lac sticks)	
Baisakhi 66-67-cum-*Katki* 67	*ber*	*ber*	1 kg	A	5	1:0	1:0	(A) Nil	—
	do	do	do	B	do	1:0	1:0	(B Nil	—
	do	do	do	C	do	1:0·20	1:190	(C) 0·170	—
	do	do	do	D	do	1:0·37	1:2·63	(D) 0·370	—
Baisakhi 67-68-cum-*Katki* 68	do	do	do	A	do	1:0	1:2·96	(A) Nil	—
	do	do	do	B	do	1:0	1:2·09	(B) Nil	—
	do	do	do	C	do	1:2·80	1:1·39	(C) 2·80	—
	do	do	do	D	do	1:3·20	1:5·45	(D) 3·20	—
Baisakhi 68-69-cum-*Katki* 69	do	do	do	A	do	1:0	1:0	(A) Nil	—
	do	do	do	B	do	1:0	1:0·1	(B) Nil	—
	do	do	do	C	do	1:3·16	1:3·07	(C) 3·76	—
	do	do	do	D	do	1:3·36	1:3·33	(D) 3·96	—
Baisakhi 69-70-cum-*Katki* 70	do	do	do	A	do	1:0	1:0·19	(A) Nil	—
	do	do	do	B	do	1:0	1:0·16	(B) Nil	—
	do	do	do	C	do	1:3·80	1:3·34	(C) 2·88	—
	do	do	do	D	do	1:4·80	1:4·09	(D) 4·08	—

Treatments: *A — Broodlac harvested 3 weeks earlier than larval emergence. B — Borodlac harvested 2 weeks earlier than larval emergence. C — Broodlac harvested 1 week earlier than larval emergence. D — Broodlac harvested on the date of brood emergence.

to find out the optimum brood rate, further trials were initiated from October 1969 with still higher rates.

The brood rates tried were 0·4 to 0·8 kg per tree with an increment of 0·1 kg and from 1·0 to 2·0 kg per tree with an increment of 0·2 kg from treatment to treatment. The crop was harvested as *ari* in April. The yield was highest with the brood rate of 1·8 kg per tree. It was noted that the yield from leaf stalks constituted 16 percent of the total production which would have been lost had the crop been harvested at crop maturity due to leaf fall.

2. Studies on proper time of harvesting-cum-coppicing *bhalia* (*Moghania macrophylla*) within January/February

Bhalia is a good host for raising the *Aghani* crop, but this host is neither able to sustain a normal *Jethwi* crop during the summer months nor does it show proper shoot growth after crop harvesting in July. The possibility of utilizing this host for the *Jethwi* crop for *ari* or at least a partial crop was, therefore, being examined since 1968. Due to non-availability of sufficient broodlac, the programme could not be continued and will be taken up next year.

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

This experiment was designed to compare the standard four-coupe system with a newly developed cultivation schedule. This involved pruning only in July, light inoculation after one year with half the normal brood rate, partial harvesting in January/February and complete harvesting in June/July next.

Initial inoculation was carried out for the *Aghani* 1969-70 crop which failed. Subsequent inoculations as reported earlier (*A. Rep.* 1969) could not be carried out due to non-availability of sufficient broodlac.

4. Finding out alternate hosts for *Kusmi* and *Rangeeni* strains of lac insects and conducting cultivation experiments on them

(a) *For Kusmi strain*

As reported earlier (*A. Rep.* 1969), of the three plant species namely, *galwang* (*Albizzia lucida*), *sandan* (*Ougeinia oojeinensis*) and *Moghania chappar* tried as *Kusmi* hosts, *galwang* alone had proved a satisfactory host as an alternate to and also in alternation with *kusum*. During the period under report, two new plant species namely, *anjir* (*Ficus carica*) and *putri* (*Croton oblongifolius*) were also tried along with *Moghania chappar* and *sandan*. Though *M. chappar* alone had so far carried a crop in the *Aghani* 1970-71 season, the crop was quite poor.

(b) *For Rangeeni strain*

The plant species tried as *Rangeeni* hosts included *siris* (*Albizzia lebbek*), *siran* (*A. chinensis*), *jaharphali* (*Ficus cunia*), *pakur* (*F. infectoria*), *putkul* (*F. glabella*) and *putri* (*Croton oblongifolius*). Only *jaharphali*, *pakur* and *putri* produced satisfactory crops.

5. Studies on the efficiency of different lac hosts on the survival of lac insects

This is a new item of investigation to study the comparative performance of different lac hosts for raising the *Rangeeni* and *Kusmi* crops. The hosts studied included *kusum*, *palas*, *bhalia*, *sandan*, *galwang*, *ber*, rain tree (*Samanea saman*), *khair* (*Acacia catechu*) and *kastura* (*Acacia farnesiana*) under potted condition for a comparative study of the viability and fertility of both *Rangeeni* and *Kusmi* lac insects.

In the *Jethwi* crop, the males were unexpectedly scarce which affected the development of insects in general. The crop was obtained only from *kusum* and *bhalia*, the latter showing better survival of lac insects.

In the *Katki* season nine of the ten hosts tried carried the *Rangeeni* crop, the survival of the insects was best on *palas*.

Agronomical and Genetical studies on lac hosts

6. Studies on training of major lac hosts into bushes for cultivation of lac

To reduce the cost of cultivation and facilitate agronomical measures to maximise the yield of lac, the conventional tree host species were being trained into bushes for intensive lac cultivation on a plantation basis. Of the four host species tried so far, namely, *galwang*, *ber*, *palas* and *kusum*, the first two had already been trained into suitable bushes and will now be put under trial for lac cultivation in their bush condition. *Palas* also appeared to have responded well to repeated coppicing and after three coppicings since 1967 had now been trained into convenient bush. Trials with *kusum*, however, were not encouraging and it appears that this host species is not suitable for training into bush.

7. Drought resistance studies on lac host plants

(a) *To induce drought resistance in bushy lac hosts*

(i) *Bhalia*

Bhalia has been successfully utilized to grow the *Aghani* crop of *Kusmi* lac, but as reported earlier this host is unable to sustain a normal crop during the summer months. In view of its other attractive features, the possibility of inducing drought resistance in this plant was being examined since 1968 by exposing its seeds to higher temperatures prior to sowing.

Seeds unexposed and exposed to 50°, 60° and 70°C for 74 hours (treatments t_1, t_2, t_3 and t_4 respectively) were sown in pots and also in the field. Under potted condition, plants were watered at 4, 8, 12 and 16 day interval and their transpiration rate measured. The transpiration rate was lowest in plants raised from seeds exposed to 70°C; this conforms to earlier findings (*A. Rep.* 1969).

In the field, best shoot growth was recorded in plants raised from seeds exposed to 70°C. The treatment differences, however, were not significant statistically.

(ii) *Arhar*

Similarly *arhar* (*Cajanus cajan*) was also raised this year from seeds unexposed and exposed to 50°, 60° and 70°C for 24 hours prior to sowing. Each treatment was replicated 5 times.

Here also the shoot growth was best in plants raised from seeds exposed to 70°C, although the treatment differences were not found significant statistically. These plants were brought under lac cultivation in the *Baisakhi* 1970-71 season to assess their performance as lac host during the summer months when they normally are unable to sustain a normal crop (*A. Rep.* 1958-59).

(b) *Screening of arhar varieties for lac cultivation under drought conditions*

Arhar is a lac host of regional importance, being a major host of Assam. In the plains, however, it does not take the lac insects well particularly during the summer months, and hence an attempt was made to screen the *arhar* varieties collected from different sources for their ability to sustain lac crops during the summer months. The results as given in Table 3 will show the varietal differences in regard to percent survival, plant height and shoot growth. Judging from shoot growth, NP 39 was found best. The performance of these varieties as lac host for the summer crop is now being examined.

TABLE 3 — OBSERVATIONS ON PLANT CHARACTERS OF *arhar* VARIETIES

Variety	Survival (%)	Average plant height (cm)	Total shoot length (cm)	Number of shoots
T	51·2	106·2	387·8	7·4
NP-41	84·4	165·1	922·6	9·3
NP-39	88·8	169·4	1137·5	13·0
NP-80	46·9	150·6	856·1	11·1
BR-60	67·4	147·1	1007·9	12·2
LR-1 (control)	79·4	127·7	843·4	10·1
	69·0	157·4	672·3	8·1
	76·3	128·3	828·6	9·1
7-S	92·9	164·3	1072·1	12·4
F. ratio	—	4·47**	2·80*	N.S.
S.E.	—	10·07	132·11	—
C.D. at 5%	—	29·03	384·46	—
C.D. at 1%	—	39·71	—	—

**Highly significant. *Significant. N.S. Not significant.

8. Studies on vegetative propagation of major lac hosts to obtain plants of desired characters

Earlier attempts to raise *galwang*, *ber*, *palas* and *kusum* from shoot cuttings using plant growth hormones were successful only in the case of *galwang* with IBA giving the best results (*A. Rep.* 1969). Further trials were continued with combinations of IBA×IPA, IBA×NAA and IPA×NAA at 50 and 100 ppm for the above hosts. *Bhalia* also was included for study with the hormones both individually and in combination at 50 ppm concentration. Besides *galwang*,

bhalia also responded well to hormone treatment. It will be seen from Table 4, that a combination of IBA×IPA is best for *galwang* when planted in March and IPA×NAA for *bhalia* when planted in June.

TABLE 4 — PERCENTAGE OF ROOT PLANTS FROM 10 STEM CUTTINGS (FOR EACH TREATMENT) WITH GROWTH PROMOTING HORMONES UNDER DIFFERENT SEASONS

Host	Growth promoting hormones	Concentration (ppm)	Percentage of rooted plants			
			January	March	June	September
	IBA×IPA	50	20	50	30	20
		100	10	60	40	10
galwang	IBA×NAA	50	NIL	20	10	NIL
		100	NIL	10	20	NIL
	IPA×NAA	50	NIL	30	NIL	NIL
		100	10	20	20	NIL
	IBA	50	NIL	10	10	20
	IPA	50	NIL	NIL	10	NIL
bhalia	NAA	50	10	20	30	30
	IBA×IPA	50	NIL	10	10	20
	IBA×NAA	50	NIL	10	NIL	NIL
	IPA×NAA	50	10	20	50	30

9. Cytotaxonomic and mutation studies on lac hosts

Cytotaxonomic and mutation studies were taken up with a view to develop improved varieites of lac hosts with greater resistance to varying climatic conditions for intensification of lac production.

(i) *Cytotaxonomic studies*

Chromosome number for *bhalia, Moghania chappar*, rain tree, *and* ~~kasura~~ Khair *was* determined as $2n = 22$, 22, 26 and 26 respectively. Further three varieties of *arhar* were also taken up for their comparative chromosome morphology. These varieties possess the same chromosome number ($2n = 22$) but they differ in total chromatin length and in the number of symmetrical and asymmetrical chromosomes.

(ii) *Mutation studies*

Seeds of *bhalia, arhar* (annual and perennial) and *M. chappar* were irradiated with gamma rays from a Co^{60} source at 5, 10, 15, 20, 25, 30, 35 and 40 Kr. Plants from irradiated seeds were raised in the field in a randomised block design. Table 5 shows that the plant growth is adversely affected with higher doses of irradiation.

(iii) *Induction of polyploidy in bhalia through colchicine treatment*

It was reported earlier (*A. Rep.* 1969) that one of the *bhalia* plants treated with 0·5 percent aqueous solution of colchicine at the seedling stage showed morphological differences. Cytological studies, however, were not possible since only insufficient number of buds were available for the purpose.

TABLE 5 — PLANT HEIGHT, NUMBER OF SHOOTS AND TOTAL SHOOT LENGTH IN IRRADIATED AND NON-IRRADIATED PLANTS

Treatments	*Moghania macrophylla*			*Moghania chappar*			*Cajanus cajan* (*Annual*)			*Cajanus cajan* (*Perennial*)		
	Average plant height (cm)	No. of shoots per plant	Total shoot length (cm)	Average plant height (cm)	No. of shoots per plant	Total shoot length (cm)	Average plant height (cm)	No. of shoots per plant	Total length (cm)	Average plant height (cm)	No. of shoots per plant	Total shoot length (cm)
Control	70·7	6·1	343·7	52·5	1·6	104·2	53·14	1·54	93·73	37·95	0·72	46·6
5 Kr	63·3	3·6	203·8	60·5	2·2	134·3	57·2	2·25	109·68	29·2	0·26	31·6
10 Kr	71·8	5·6	291·3	53·3	1·9	116·9	48·59	1·84	92·36	28·6	0·18	29·5
15 Kr	63·5	4·4	250·2	62·9	1·9	127·4	53·58	3·61	126·65	30·42	0·66	36·5
20 Kr	65·8	4·5	241·8	56·7	1·4	99·1	50·69	2·66	118·31	33·16	0·64	47·22
25 Kr	56·4	3·3	177·03	46·4	0·55	65·06	53·92	2·24	92·3	33·54	0·94	43·0
30 Kr	46·8	2·5	139·06	55·4	2·2	128·3	51·35	2·17	98·41	26·45	0·46	29·89
35 Kr	63·5	3·1	179·8	57·2	1·6	102·0	56·31	3·07	128·38	35·88	0·52	39·24
40 Kr	54·5	2·8	155·1	—	—	—	43·7	2·36	78·33	25·92	1·00	27·75

Bhalia plants were again raised from seedlings both from untreated and treated with 0·25, 0·50, 0·75 and 1·00 percent concentration of aqueous solution of colchicine.

The average plant height and shoot number were reduced with the increase in concentration of colchicine. Subsequent cytological studies will be made when flower buds are available during September-October 1971.

Physiological studies

10. Nutritional requirements of lac insects

The item could not be pursued as the worker resigned.

11. Microbiological studies on lac insects

Both *Rangeeni* and *Kusmi* strains of lac insects were reared, the former on *ber* and *ghont* and the latter on *kusum*. These strains were then examined for differences, if any, in their microflora.

Preliminary results showed that two species (*Micrococcus varians* and *M. conglomeratus*) are common to both the strains when reared on their respective hosts. Apart from these, further isolation was made of one species from the lac insects reared on *ghont* (*Rangeeni*), three from *ber* (*Rangeeni*) and two from *kusum* (*Kusmi*). These species are yet to be identified.

Biochemical tests showed that *M. varians*, *M. conglomeratus*, *Clostridium* sp. and *Bacillus subtilis* fermented glucose, sucrose, lactose and mannitol, could not digest cellulose or convert tryptophan to ammonia, pyruvate and indole; produced acetyl methyl carbinol. Heavy peptonization of milk was brought about by all; starch was hydrolysed by all except *B. subtilis*, hydrogen sulphide was produced by all except *Clostridium* sp. and gelatin was liquified by all except *M. varians*.

Breeding and Genetical studies on lac insects

12. Breeding for better lac insects

Earlier studies had shown that the conventional *Rangeeni* host, *palas* which produces the bulk of lac of commerce, is unable to support the superior *Kusmi* strain of lac insects because it is not in the right physiological state during the *Kusmi* cycles (*A. Rep.* 1969). The possibility of combining the *Kusmi* resin quality and *Rangeeni* cycles is, therefore, being examined in crosses of the *Rangeeni* and *Kusmi* strains of lac insects in an attempt to have the desired insect for large scale production of the superior *Kusmi* lac on *palas*.

The F_1 from reciprocal matings of the two strains behaved like the maternal stock. Subsequent progenies (F_2 generation) are awaited for further study.

13. Genetic analysis of chromosome behaviour in lac insects

The cytological picture in lac insects remains confused due to contrary reports on its chromosome number and behaviour. Thus, while Tulsyan (1963)

reported a normal chromosome behaviour with XX; XO sex mechanism, Dikshith (1964) suggested the unorthodox 'Lecanoid' system as unravelled in the mealy bug, *Planococcus-citri* (Risso). In this system the paternal chromosome set becomes heterochromatic in the early embryonic stage of the male, which is retained as a genetically inert component during further development and is finally discarded during spermatogenesis, so that the male expresses and transmits only the maternally derived genes.

The colour difference (crimson and yellow) is inherited as a unit character and the crimson is dominant to yellow. The progeny phenotype in the F_1, F_2 and backcross generations in crosses of these colour strains could thus be used to test which of the two systems proposed on cytological evidence actually obtains in lac insect.

Table 6 shows that the colour strains used in these experiments were homozygous for the type. Reciprocal matings between the colour strains produced only the crimson sons and daughters, indicating that the colour difference is not sex-linked and that the male is somatically a diploid.

The F_2 data demonstrate that the classical Mendelian inheritance was not obtained in lac insects. The phenotype of the F_2 generation differed according to the direction of cross of the F_1 parents.

TABLE 6 — PROGENY PHENOTYPES IN CROSSES OF CRIMSON (Y) AND YELLOW (y) STOCKS OF LAC INSECTS

Generation	Genotype of		Number progenies	Daughters		Sons	
	Mother	Father		Crimson	Yellow	Crimson	Yellow
Parent	YY	YY	11	1003	0	467	0
	yy	yy	10	0	607	0	367
F_1	YY	yy	12	1099	0	617	0
	yy	YY	14	979	0	407	0
F_2	Y(y)	Y(y)	10	991	0	579	0
	y(Y)	y(Y)	11	401	332	212	137
Backcross	y(y)	y(Y)	14	0	907	0	391
	y(y)	Y(y)	10	891	0	516	0
	y(Y)	y(y)	11	498	676	281	217
	Y(y)	y(y)	14	527	508	346	231

(The allele contributed by the father is shown in parentheses)

Thus, while yellow females mated to crimson males produced the two colour forms in the F_2 generation — this segregation was completely absent in the reciprocal cross. One sex in the F_1 generation was, therefore, suspected of producing only one kind of gamete.

The F_1 males and females when testcrossed to the yellow mates confirmed that while heterozygous females produced two kinds of gamete, heterozygous males produced only the maternal kind since they produced exclusively either the yellow or crimson progeny depending upon whether they had the yellow or the crimson mother. The elimination of paternal gene, and hence the chromosome, was confirmed during the formation of male sex-cells, which also explains the unusual F_2 results.

The genetic evidence thus rules out both the normal and the 'Lecanoid' systems of chromosome behaviour. Instead, the available evidence is suggestive of a chromosome system with heterochromatization and elimination of paternal chromosomes confined to the male germ line.

Study of strain crosses had shown (*vide* item 15) that the *Kusmi* strain is genetically endowed for normal survival on *kusum*, but not the *Rangeeni* and the ability of *Kusmi* to survive on *kusum* is dominant to the inability of *Rangeeni* to do so. This characteristic physiological difference could be used to test further the somatic state of paternal chromosomes in the lac insect. If the paternal chromosomes are indeed inactivated as in the 'Lecanoid' system we can expect that progenies from *Rangeeni* mothers and *Kusmi* fathers will comprise negligible or no males at all on *kusum*. Ten progenies were scored from each class of mating. Table 7 shows the progeny sex ratio in crosses of *Rangeeni* and *Kusmi* stocks of lac insects.

Comparison of sex ratio will show that the hybrid progenies from *Rangeeni* mothers and *Kusmi* fathers comprise both sons and daughters and the proportion of sons does not differ significantly from that in the *Kusmi* progenies. This study provides further evidence of somatic diploidy of the lac insect male.

TABLE 7 — AVERAGE SEX RATIO IN CROSSES OF *Rangeeni* AND *Kusumi* STOCKS OF LAC INSECTS

Cross		Progeny sex ratio			
Mother	Father	Number	Males	Females	% Males
Kusmi	*Kusmi*	1755	204	1551	11·6
Rangeeni	*Kusmi*	1157	167	990	14·4

14. Mutation studies in lac insects

With a view to induce economically desirable mutations, isolated *Kusmi* females on potted *bhalia* plants were exposed to 2000 and 4000 r X'rays in their second instar. At sexual maturity, each irradiated female was mated to a male from laboratory cultures. Their progenies are expected in February/March 1971.

15. Genetic evidence of nutritional differences in lac insects

The *Rangeeni* and *Kusmi* strains of lac insects are morphologically similar and both are bivoltine but they differ in their life periods and in the choice of their food plant. Thus, the *Kusmi* strain occurs in nature on *kusum* which plant is well known not to take the *Rangeeni* strain. This difference might be expected due to either differential nutritional requirements of these strains or to differential physiological state of the plant during their different periods of growth and reproduction.

Study of crosses have shown that the *Rangeeni* females mated to the *Kusmi* males produce progeny which retains the *Rangeeni* life period in the rainy season generation and yet show the normal *Kusmi* survival on *kusum*

(Table 8). Thus, introduction of one haploid set of *Kusmi* chromosomes allows the insects to survive normally on *kusum* during the period when the *Rangeeni* insects show negligible or no survival at all. This evidence shows that the *Kusmi* strain is genetically endowed for survival on *kusum* and the ability of *Kusmi* strain to survive on *kusum* is dominant to the inability of *Rangeeni* to do so. The chemical basis underlying their differential survival on *kusum* presents an interesting field of enquiry for future work on lac insects.

TABLE 8 — AVERAGE PROGENY SURVIVAL IN CROSSES OF *Rangeeni* AND *Kusmi* STOCKS OF LAC INSECTS ON *Kusum*

Cross		Progeny survival		
Mother	Father	Number tested	Survival (%)	Life period
Kusmi	*Kusmi*	2717	64·6	July to February
Rangeeni	*Rangeeni*	2260	0·7	July to October
Rangeeni	*Kusmi*	1938	59·7	July to October

16. Sex ratio studies in lac insects

A study of sex ratio in the different batches of larval emergence within individual progenies of lac insects has shown that the proportion of males is highest in the earliest batch of emergence and then declines rather sharply and progressively in the subsequent batches, reducing to half and one-third in the final batch of emergence in the rainy and dry season generations respectively, indicating a greater environmental role in the determination of sex in these insects.

17. Multiple coitus and its biological significance in lac insects

It is well known that lac insect males do not feed throughout their immature stages nor after they emerge as adult. They are nevertheless highly active in mating and copulate with a large number of females during their short adult life of a few days. The fecundating capacity of the male was judged by collecting five newly emerged males and offering them as many females as they could copulate with. The males mated with 45 females on the average, the range being 35 to 58.

In the laboratory cultures of these insects, more than one male were often found attempting simultaneous coitus with one female, but only one succeeded at a time. The female, after mating, remained attractive to males and mated a number of times. A single female was mated to nineteen different males within a short period of 40 minutes. Whether the different males mating with one female were each effective in fertilising the female was tested using the colour mutant (yellow) in these insects. The yellow females were mated each to both yellow and crimson males and the progeny phenotype used to detect how the progeny was derived. Ten such progenies were reared in the laboratory. The progeny in each case consisted of both yellow and crimson insects, confirming that the different males used were each effective in fertilising the female.

The frequency of females mating more than once in nature was ascertained by collecting 20 yellow females at random from the mixed colonies of the two colour strains in nature and rearing their individual progenies in the laboratory. Nineteen of these progenies consisted of both yellow and crimson insects in varying proportions, indicating that multiple coitus is a rule rather than exception in nature.

The successful fertilization of lac females by different males thus appears to provide a mechanism for the maintenance of genetic variability in their natural aggregates. Otherwise their peculiar breeding structure would tend to promote inbreeding and consequent loss of genetic variability.

Biological control of enemies of lac insect

18. Survey of different diseases occurring in lac insect predators, *Eublemma amabilis* and *Hlococera pulverea*

Two bacterial diseases have been detected in the larvae of *E. amabilis* collected in the field. These bacteria were isolated and their pure cultures maintained for routine identification and for establishing the disease further tests will be done.

19. Studies on the artificial rearing of the beneficial parasites attacking lac insect predators

This is a new item of investigation taken up late in the year with a view to mass breed the important beneficial parasites (parasites of lac pests) on an artificial medium for subsequent use in developing an integrated control of lac pests.

(a) The pH of haemolymph, whole insect homogenate and alimentary canal of the lac insect predators, *Eublemma amabilis* and *Holcocera pulverea*, was determined using pH indicator paper (BDH). It was found that the digestive tract of the lac insect predators is distinctly alkaline and not acidic as has been reported by earlier workers.

(b) The alimentary canal of *E. amabilis* was dissected out, washed, homogenized and centrifuged and the supernatant tested for the presence of the digestive enzymes. The enzymes detected include amylase, maltase, invertase, lactase, lipase, pepsin and trypsin. This indicated that the food of *E. amabilis* should comprise sucrose, lactose, fats and proteins.

(c) Attempts were also made to study the sugar content of the haemolymph of lac insect predators using paper partition chromatography, but no suitable solvent system could so far be found for the purpose.

20. Seasonal incidence and behavioural studies on beneficial insects associated with lac insects

These studies were taken up to screen the important beneficial parasites which could be used in integrated control of lac pests.

An initial start was made by studying the seasonal incidence on tree and bushy host species which were used to raise lac crops. Collection of 0·5 kg

lac samples was made at fortnightly interval from the time of *phunki* removal, i.e. three weeks after the lac settlement, till the time of crop maturity. These samples were caged for noting the emergence of the beneficial insects both from *Rangeeni* and *Kusmi* crops. Cropwise observations are as follows:

Jethwi 1970 — The crop condition was rather poor. Samples collected during the first two months after *phunki* removal and also thereafter, showed poor emergence of beneficial insects.

Aghani 1970-71 — This crop could not be raised due to non-availability of broodlac.

Katki 1970 — The incidence of beneficial parasites was much higher on the tree hosts than on bushes, although the pest population was observed to be otherwise.

Behavioural studies

Attempts at present are being made to rear the beneficial parasites on an alternate host *Corcyra cephalonica* in the laboratory. *Pristomerus sulci* did not mate in confinement, although it readily oviposited in the early instar larvae of the alternate host. Such oviposition resulted in unisexual progeny comprising males only. However, *Eurytoma palidiscapus* and *Elasmus claripennis* were successfully reared in the laboratory on the same alternate host. Laboratory cultures of these insects will be raised for detailed study.

21. Studies on the pests of lac hosts trees and their control

(i) *Studies on Limacodid pests*

Lac is mostly grown on forest trees and since limacodids are well known defoliators of such trees, biological studies of these pests were undertaken with a view to screen the economically important pests and to develop suitable control measures against such pests. The different aspects of detailed studies made are as follows :

a) *Food habits*

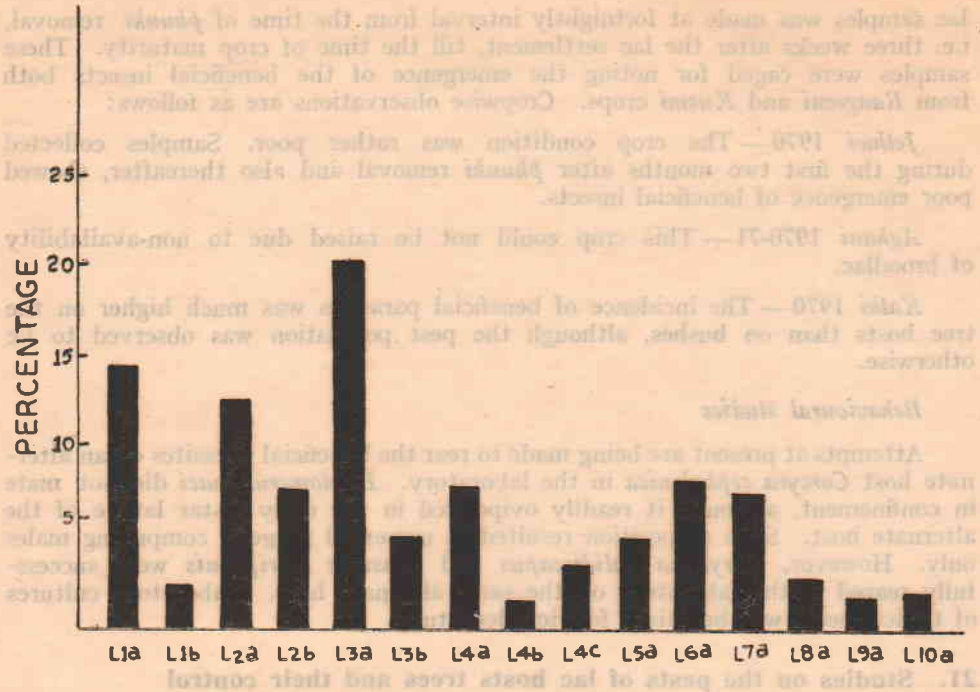
Eighteen species belonging to ten genera have been recorded as pests of major, occasional and rare lac hosts from the Institute plantation at Namkum.

b) *Species composition and seasonal incidence*

Periodical collections of limacodids from lac hosts had shown that the most common and prevalent is *Beliappa laleana* Moore. Other important limacodids include *Miresa albipuncta* Herr.Schff., *Thosea* sp., *Scopelodes* sp., *Parasa* sp., *Narosa doenia* Moore, *Altha* sp., *Natada* sp., *Macroplectra* sp., and others as shown in Figs. 1 and 2, which also show their seasonal incidence.

c) *Degree of infestation*

Table 9 shows density of pest larvae and the percentage host infested for *palas*, *ber* and *kusum* trees. The incidence of *B.laleana* was the highest on all the lac hosts. Other important pests in this regard were *Miresa* sp., *Thosea* sp., *Scopelodes* sp., *N.doenia*, *Altha* sp. and *Parasa* sp. in descending order of infestation.



ANNUAL DIFFERENCES IN THE COMPOSITION OF THE LARVAE OF LIMACODID SPECIES

Fig. 1

L_1a — Miresa albipuncta. L_1b — Miresa sp. L_2a — Parasa lepida. L_2b — Parasa sp. L_3a — Belippa laleana. L_3b — Belippa sp. L_4a — Thosea sp. L_4b — Thosea sp. L_4c — Natada sp. L_5a — Narosa doenia. L_6a — Scopelodes sp. L_7a — Altha sp. L_8a — Macroplectera sp. L_9a — Cania sp. $L_{10}a$ — Unidentified sp.

d) *Life history studies*

Life history of some of the important limacodid pests (e.g. *Parasa* sp., *N.doenia*, *N.albipuncta*, *Scopelodes* sp., and *Thosea* sp.) was studied. These pests passed through two generations in the year excepting *N.doenia* which had three generations and *Scopelodes* sp. only one. The durations of the stages of the pests are presented in Table 10.

Parasites and diseases were noted as follows :

Two Ichneumonids — one from *B. laleana* and the other from *Thosea* sp. and *Altha* sp.

Three braconids — of which one is common to *B.laleana* and *N.doenia* and the other two belonging to two species were from *Miresa* sp. and *Altha* sp. Three different species of chalcids-one each from *Parasa* sp., *Altha* sp. and *B. laleana* and two different species of nematodes from *B.laleana* and *Thosea* sp.

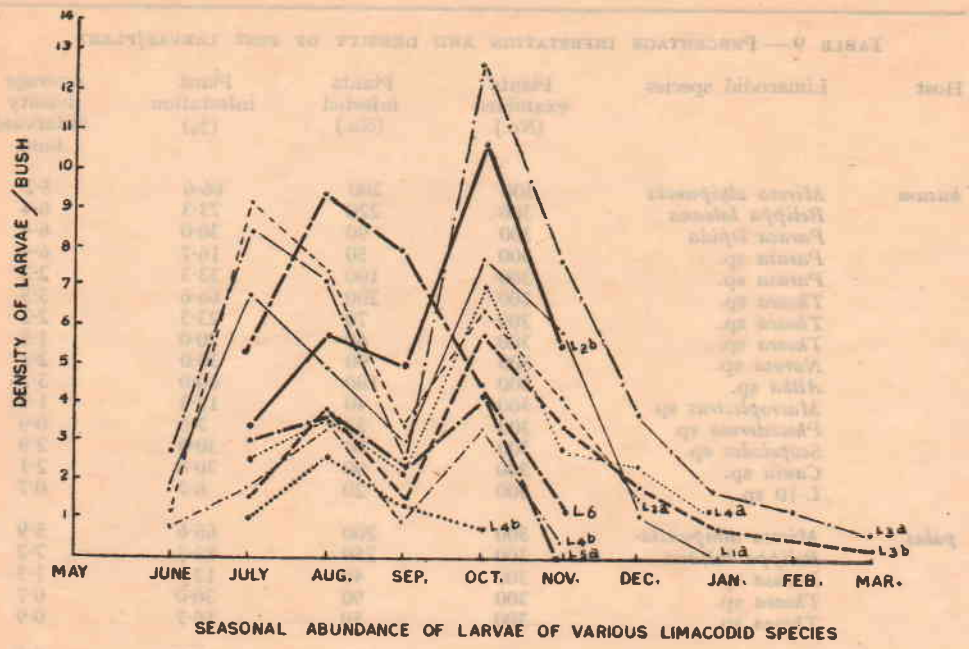


Fig. 2

L_1a — Miresa albipuncta. L_1b — Miresa sp. L_2a — Parasa lepida. L_2b — Parasa sp. L_3a — Belippa laleana. L_3b — Belippa sp. L_4a — Thosea sp. L_4b — Thosea sp. L_5a — Narosa doenia. L_6 — Scopelodes sp.

The above mentioned insects still remain to be identified.

Further, two highly pathogenic microorganisms were also isolated. One, a chromogenic spore forming bacteria was found to occur in *Parasa* sp., *Scopelodes* sp. and *Thosea* sp. and the other which is not chromogenic but spore forming was found in *Miresa* sp. and *B.laleana*. These are also being identified.

(ii) The control studies were continued this year also.

(a) *Laboratory trials against pests of bhalia*

D.D.T. 25 E.C., Dieldrex 18 E.C., Endrex 20 E.C. and Thoidan 35 E.C. were each tried at 4 concentrations namely, 0·01, 0·05, 0·10 and 0·15 per cent against larvae of *Hypena iconicalis*, *Hemithea tritonaria* and *Platypeplus aprobola*.

Pest larvae were collected from the field and preconditioned for 24 hours by feeding them on *bhalia* leaves in the laboratory. Twentyfive larvae of each pest were then collected at random and grouped into 5 batches of 5 each to form 5 replications including a control for each insecticide. The pest larvae were released on filter papers impregnated with various concentrations of insecticides as indi-

TABLE 9 — PERCENTAGE INFESTATION AND DENSITY OF PEST LARVAE/PLANT

Host	Limacodid species	Plants examined (No.)	Plants infested (No.)	Plant infestation (%)	Average density of larvae/ bush
kusum	*Miresa albipuncta*	300	200	66·6	5·2
	Belippa laleana	300	220	73·3	6·4
	Parasa lepida	300	90	30·0	6·4
	Parasa sp.	300	50	16·7	6·4
	Parasa sp.	300	100	33·3	2·2
	Thosea sp.	300	200	66·6	3·5
	Thosea sp.	300	70	23·3	2·2
	Thosea sp.	300	60	20·0	1·5
	Narosa sp.	300	90	30·0	2·1
	Altha sp.	300	180	60·0	3·2
	Macroplectras sp.	300	40	13·3	1·2
	Phecoderma sp.	300	23	7·6	0·9
	Scopelodes sp.	300	90	30·0	2·9
	Cania sp.	300	90	30·0	2·1
	L-10 sp.	300	20	6·7	0·7
palas	*Miresa albipuncta*	300	200	66·6	5·9
	Belippa laleana	300	250	83·3	7·2
	Parasa sp.	300	40	13·3	1·3
	Thosea sp.	300	90	30·0	0·7
	Thosea sp.	300	50	16·7	0·9
ber	*Belippa* sp.	150	48	32·0	2·6
	Narosa sp.	150	35	23·3	1·5
	Altha sp.	150	20	13·3	0·5
	Thosea sp.	150	18	12·0	0·7
	Belippa sp.	150	30	20·0	1·6

cated above and the mortality recorded after 24 hours. The moribund larvae were considered as dead. The efficiency of the insecticides was judged on the basis of the mortality within 24 hours of release of pests. From the data set out in Table 11 it is found that Thiodan 35 E.C. was most effective against *H.tritonaria*, *H.iconicalis* and *P.aprobola* and Endrex 20 E.C. against the latter two.

(b) *Field trials against pests of bhalia*

Three concentrations namely, 0·1, 0·15 and 0·2 per cent of DDT 50% WP, DDT 25 E.C., Dieldrex 18 E.C., Endrex 20 E.C. and Thiodan 35 E.C. were tried against *H.iconicalis*, *H.tritonaria*, *Nephopteryx leucophaella* Zell. and *P.aprobola*.

The experiment was carried out on a randomised block design with 25 bushes in each treatment with 4 replications.

Pest population was assessed 24 hours before spraying and mortality recorded 24 hours after each spraying. Data are set out in Table 12.

It will be seen from the table that Endrex 20 E.C. and Thiodan 35 E.C. were most effective against all the pests, while Dieldrex was effective only against *H.iconicalis*.

TABLE 10 — DURATION OF VARIOUS STAGES IN THE LIFE HISTORY OF VARIOUS LIMACODID PESTS OF LAC HOST TREES IN DAYS

Host plant	Pest	Gene-ration	Date of egg laying	Egg stage (days)	Larval instarts (days)									Pupa (days)	Egg to adult (days)
					1st	2nd	3rd	4th	5th	6th	7th	8th	9th		
				7·2	7·2	8·2	6·5	6·5	6·9	8·2	—	—	—	30·2	51·3
Kusum	*Parasa*	I	10-8-70	(6-8)	(6-8)	(7-9)	(6-7)	(6-7)	(7-8)	(8-9)				(27-31)	(50-54)
		II	30-9-70	7·7 (7-8)	8·2 (8-9)	7·2 (7-9)	6·9 (6-8)	6·9 (6-8)	8·2 (7-9)	6·5 (6-7)	—	—	—	under	pupation
kusum, ber & bhalia	*Narosa doenia*	I	24-6-70	6·6 (6-7)	8·2 (7-9)	6·7 (6-8)	8·2 (8-9)	9·3 (9-10)	8·2 (7-9)	6·9 (6-8)	—	—	—	23·6 (20-25)	48·2 (46-49)
		II	20-8-70	6·7 (6-8)	6·6 (7-9)	8·2 (7-9)	6·6 (6-7)	7·9 (7-8)	7·9 (7-8)	7·9 (7-8)	—	—	—	26·9 (23-29)	52·2 (50-54)
		III	28-9-70	6·9 (6-9)	6·6 (6-7)	6·6 (6-7)	6·7 (6-8)	6·7 (6-8)	7·9 (7-8)	6·9 (6-9)					
kusum, palas	*Miresa albipunta*	I	6-7-70	8·3 (7-9)	8·3 (7-9)	7·9 (7-8)	6·8 (6-8)	7·9 (7-8)	8·3 (7-9)	8·7 (8-9)	7·9 (7-8)	—	—	34·6 (33-35)	— 98·7
		II	30-10-70	7·6 (7-8)	6·8 (6-8)	8·3 (7-9)	6·8 (6-8)	8·7 (8-9)	6·8 (6-7)	8·7 (8-9)	7·9 (7-8)	—	—	under	pupation
kusum, sal	*Scopelodes* sp.	I	8-7-70	8·2 (7-9)	8·5 (8-9)	8·7 (8-10)	9·4 (9-10)	8·2 (7-9)	6·5 (6-7)	8·5 (8-9)	8·2 (7-9)	8·9 (8-10)	8·5 (8-9)	35·6 (30-37)	— —
kusum, ber & sal	*Thosea* sp.	I	10-7-70	7·8 (7-9)	7·6 (7-8)	6·7 (6-8)	8·6 (8-9)	7·6 (7-8)	6·7 (6-7)	9·2 (9-10)	6·5 (6-7)	—	—	32·2 (32-35)	— 82·9
		II	7-10-70	6·7 (6-8)	6·5 (6-7)	7·6 (7-8)	7·6 (7-8)	6·8 (6-8)	8·7 (8-9)	7·6 (7-8)	8·9 (8-10)	—	—	under	pupation

TABLE 11 — LABORATORY TRIALS AGAINST PESTS OF BHALIA

Pest	Percentage mortality after 24 hours of release															
	D.D.T. 25 E.C., %				Dieldrex 18 E.C., %				Endrex 20 E.C., %				Thiodan 35 E.C., %			
	0·01	0·05	0·10	0·15	0·01	0·05	0·10	0·15	0·01	0·05	0·10	0·15	0·01	0·05	0·10	0·15
H. tritonaria	0·0	0·0	26·6	33·3	—	60·0	66·6	100·0	26·6	33·3	66·6	100·0	33·3	100·0	—	—
H. iconicalis	86·6	100·0	100·0	—	76·6	80·0	86·6	100·0	100·0	100·0	—	—	100·0	100·0	100·0	—
P. aprobola	0·0	0·0	53·3	80·0	46·6	53·0	66·6	73·3	40·0	60·0	80·0	100·0	26·6	86·6	93·3	—

TABLE 12 — FIELD TRIALS AGAINST PESTS OF BHALIA

Pest	Percentage mortality 24 hours after spraying														
	D.D.T. 50 % W.P.,			D.D.T. 25 E.C., %			Dieldrex 18 E.C., %			Endrex 20 E.C., %			Thiodan 35 E.C., %		
	0·10	0·15	0·20	0·10	0·15	0·20	0·10	0·15	0·20	0·10	0·15	0·20	0·10	0·15	0·20
H. tritonaria	57·1	66·6	57·1	50·0	66·6	100·0	83·3	91·1	66·6	100·0	100·0	100·0	90·9	100·0	100·0
H. iconicalis	83·3	80·0	80·0	100·0	100·0	100·0	83·3	87·5	87·5	100·0	100·0	100·0	100·0	100·0	100·0
N. leucophaella	42·8	50·0	50·0	50·0	60·0	80·0	45·5	75·0	80·0	83·3	85·7	87·5	75·0	80·0	85·7
P. aprobola	49·7	59·3	85·5	55·0	74·0	89·5	54·7	68·8	81·4	92·1	92·1	92·3	91·6	78·7	90·2

Ecological studies on lac insects

22. Studies on the influence of photoperiods on lac insect

The effect of photoperiods on lac insect (*Kusmi* and *Rangeeni* strains) development is being studied since October 1968 by exposing 50 isolated insects on potted *bhalia* plants to varying periods of day and night lights. The growth rate was measured by noting the times of moulting; besides this sex-ratio, and fecundity and life cycle were also determined.

The exposures to light were :

24 hour exposure to natural light, 13, 10 and 7 hour exposures to day light, no exposure to light at all and 11 hour exposure to night light.

The results indicated that the lac insects are not directly affected by exposure to varying photoperiods.

The experiment, however, will be continued further by exposing the host plants to these treatments prior to inoculation and continued till the maturity of the insects.

Regional Field Research Station for Lac, Dharamjaigarh

(i) *Evolution of a suitable cultivation practice to be followed for kusum :*

The experiment has been designed to determine a suitable cultivation practice to be followed for *Kusum* in the environs of Madhya Pradesh.

The experiment is carried out with the following treatments.

Treatment A —	A_1I	— Inoculation in December and final harvest in December next.
(1 yr. rest)	A_1II	— -do-
	A_2I	— Inoculation in July and final harvest in July next.
	A_2II	— -do-
Treatment B —	B_1I	— Inoculation in December and final harvest in December next.
(2 yr. rest)	B_1II	— -do-
	B_1III	— -do-
	B_2I	— Inoculation in July and final harvest in July next.
	B_2II	— -do-
	B_2III	— -do-
Treatment C —	C I	— Inoculation in December and final harvest in July.
(1½ yr. rest)	C II	— Inoculation in July and final harvest in December.
	C III	— Inoculation in December and final harvest in July.
	C IV	— Inoculation in July and final harvest in December.
Treatment D —	Villagers method — only part of the tree is inoculated and harvested every season.	

Crop — *Jethwi-cum-Aghani* 1970

Since all the trees have come under regular pruning cycle, it will now be possible to compare the different practices from July 1971 from the inoculations made in July 1970.

The data obtained from inoculations carried out in December 1969 cannot be considered for comparison between various practices under trial as inoculation of all the trees under the experiment could not be carried out due to nonavailability of the required quantity of broodlac.

The inoculations, as per schedule, for *Aghani*-cum-*Jethwi* 1970-71 were carried out as indicated below in July 1970.

Crop — *Aghani-cum-Jethwi*

Inoculation data are as follows :

Treatments	No. of trees	Brood used kg.	Phunki Lac sticks kg.	Phunki scraped kg.
A_2II (1 yr. rest)	15	27·0	14·4	7·0
B_2I (2 yr. rest)	15	40·0	21·7	10·6
C III (1½ yr. rest)	15	54·0	26·8	13·5
D (Villager's method)	15	48·0	21·6	11·1

Observations made at the time of *phunki* removal and male emergence after artificial inoculation are as follows :

Treatments	At phunki removal. No. of cells per 2·5 cm	Mortality (%)	At male emegernce. No. of cells per 2·5 cm	Male (%)	Female (%)
A_2II	167·45	41·54	12·50	34·37	65·61
B_2I	54·00	40·92	12·05	34·54	65·55
C III	71·20	37·37	14·20	27·27	72·71
D	39·27	40·35	18·52	27·28	68·71

(ii) (a) *Investigation of likely Kusmi hosts occurring in the region*

Khair (*Acacia catechu* Willd.), *sarai* (*Shorea robusta*), *dhobein* (*Dalbergia paniculata* Roxb.), *dummar* (*Ficus racemosa* Linn.) and *bansa* (*Albizzia odoratissima* Benth.) were tried as lac hosts during *Aghani* 1969-70, *Jethwi* 1970 and *Aghani* 1970-71 seasons for raising the *Kusmi* lac. Only *khair* yielded 0·8 kg (5 trees inoculated with 4·0 kg broodlac) and 2·3 kg (5 trees inoculated with 3·5 kg broodlac.) broodlac during *Aghani* 1969-70 and 1970-71 respectively.

(ii) (b) *Selection and introduction of suitable regional or exotic hosts to fortify cultivation of Kusmi lac*

Plantation of *bhalia* and *galwang* is being raised on the land recently handed over by the Forest Department, Madhya Pradesh, for trials of these lac host separately under climatic conditions of Madhya Pradesh.

(iii) *General survey of the enemies of the lac insects and their parasites*

The survey of inimical insects was continued. It was found that predators were more prevalent than parasites. A few new insects have been collected from caged *Jethwi* 1970 brood lac purchased from Girsa village. They are being sent to British Museum for identification.

(c) RESEARCHES CONTEMPLATED

Only two among the other studies in progress during the previous years were completed during the year under report. The remaining ones will be continued. Further, out of the seven items contemplated for the year (*A.Rep.* 1969) six were taken up for investigation and are now in progress. Besides, following studies are contemplated to be taken up during the next year.

1) Studies on brood rate trials under the major project 'Lac cultivation studies'.
2) Possibility of controlling lac predators by chemical sterilisation under the major project 'Integrated control of inimical insects'.
3) Culture of lac on plantation basis on trained bushes under the major project 'Intensive lac cultivation under bushy conditions'.
4) Under the major project influence of environmental factors, a study will be initiated to determine harvesting of broodlac in different regions through the use of biometer.

(B) CHEMISTRY DIVISION

(a) RESEARCHES IN HAND

1. Improvement in manufacture of seedlac and shellac

(a) *Preparation of shellac directly from sticklac*

It has been reported (*A.Rep.* 1968) that shellac of satisfactory properties can be produced directly from sticklac by extraction of the latter with alcohol or acetone and recovering the resin either by precipitation with 1 per cent aqueous salt solution or by distilling off the solvent. The main advantage of this new method over the conventional one is in higher yield of shellac with better life and flow.

The standardised method reported last year was extended to different types of 7 kg lots of sticklac and the properties and yield of shellac are brought out in

Table 13: The respective data for shellac prepared by *bhatta* method from seedlac are also given for comparison.

From the Table 13 it will be seen that the products obtained by the direct process are of darker colour. In order to remove this dark colour, absorbents like zinc carbonate, magnesium carbonate, calcium carbonate, caprolactum powder and activated carbon were tried. Activated carbon was found to be the best and 8-10 per cent of carbon was necessary for *Rangeeni* and 4-5 per cent for *Kusmi* sticklacs so as to obtain shellac of colour index equal to that of *bhatta* shellac. The absorption process brought down the yield of shellac from sticklac by only 2 to 3 per cent.

TABLE 13 — PROPERTIES OF SHELLAC PRODUCED DIRECTLY FROM STICKLAC

Sl No.	Sticklac used	Temp. & medium of extraction	Yield (%)	Colour index	Life (minutes)	Flow (mm)	Wax (%)
1.a	*Ber*	Acetone at 40°C	76·4	22	45	104	4·4
b	,,	Acetone at 20°C	72·0	21	48	106	0·16
c	,,	*Bhatta*	60·0	14	43	83	4·4
2.a	*Palas*	Acetone at 40°C	72·2	26	44	102	4·1
b	,,	Alcohol at 20°C	69·0	24	46	104	0·14
c	,,	*Bhatta*	54·6	17	41	81	4·3

When 100 per cent of carbon was used for decolourisation in two instalments, products of colour indices of 1·6 and 1·3 were obtained from *Rangeeni* and *Kusmi* sticklac respectively. The loss in yield in these cases were of the order of 8 to 10 per cent. The results have been brought out in Table 14.

TABLE 14 — EFFECT OF ACTIVATED CARBON ON DECOLOURISATION

Quality of lac used	Mode and medium of extraction	Amount of carbon used (%)	Yield (%)	Colour index	Life (minutes)	Flow (mm)	Wax (%)
Rangeeni	Alcohol at 20°C	0	73	18·0	43	104	0·17
,,	do	10	70	10·5	42	102	0·15
,,	do	100	63	1·4	42	103	0·13
,,	Acetone at 40°C	0	75	18·0	42	104	4·2
,,	do	10	72	11·0	42	103	4·0
,,	do	100	66	1·6	41	103	3·8
,,	*Bhatta*	—	58	12·0	40	88	4·4
Kusmi	Alcohol at 20°C	0	80	11·5	38	100	0·16
,,	do	4	78	8·5	37	98	0·14
,,	do	100	71	1·2	36	98	0·12
,,	Acetone at 40°C	0	84	13·5	40	100	4·1
,,	do	4	81	8·0	38	99	4·0
,,	do	100	73	1·3	37	98	3·9
,,	*Bhatta*	—	61	10·0	36	82	4·4

The process was repeated several times with 10 kg lots of sticklac and was found reproducible.

The process not only produces waxy or dewaxed shellac directly from sticklac in higher yields with better life and similar colour index but also can produce decolourised dewaxed as well as waxy shellac. The decolourised waxy shellac will be a new addition to the existing shellacs of commerce.

The residue left over after solvent extraction contained the whole of wax and dye along with insect debris and other insoluble impurities. The lac wax and the water soluble dye (20-25 per cent and about 4 per cent respectively on the weight of the residue) was recovered from the residue by extraction with hexane and water respectively.

(b) *Modification of shellac wax*

This problem could not be taken up as the investigator was completely engaged in the work under (a) therefore the problem was kept in abeyance.

(c) *Dewaxing of shellac in aqueous medium*

The demand of dewaxed lac is gradually increasing because of the clear varnishes and films it produces. The conventional method for the production of dewaxed lac is by solvent and aqueous methods. The former is a costly one and the latter though cheap, is time-consuming and laborious.

The possibility of dewaxing lac economically by the aqueous method was investigated. The method reported earlier (*A.Rep.* 1963-64, p. 22-23) was repeated. In this method the major portion of wax was recovered as a scum from the cold sodium carbonate solution of shellac. For removal of the suspended wax, the lac solution was boiled once again and barytes (50 per cent on the weight of lac content) was added.

On standing, the wax settled along with barytes but during filteration fine barytes particles were found to pass along with the filtrate.

Some preliminary work by the addition of sufficient amount of lac wax to the boiling alkaline lac solution was also carried out. The wax on cooling formed a compact mass on the surface carrying most of the wax present in the lac solution. This method appeared to be promising.

(d) *Bleaching of lac with chlorine free oxidising agents*

(i) *With hydrogen peroxide alone*

Since the entry of chlorine in shellac during bleaching with sodium hypochlorite adversely affects the life and flow, the use of chlorine free bleaching agents, such as hydrogen peroxide, was tried last year.

Continuing the work on bleaching of lac with hydrogen peroxide, it was found that for the same conditions of temperature, duration and amount of hydrogen peroxide, bleaching in sodium bicarbonate solution (15 per cent on the weight of lac) was more effective than in sodium carbonate solution. The colour index of *Rangeeni* seedlac in sodium bicarbonate solution could be reduced to 4·5 as against 7 and of *Kusmi* to 2 as against 6 in sodium carbonate solution.

The increase in the amount of hydrogen peroxide, from 75 ml to 150 ml and even to 300 ml (for 100 g of seedlac) was found to have very little effect in bringing

down the colour further. The products obtained, however, had good life under heat and flow.

The replacement of sodium carbonate and bicarbonate with ammonia for dissolving seedlac did not also improve the colour.

(ii) *Combined bleaching with sodium hypochlorite and Hydrogen peroxide*

Since the colour indices of the bleached products could not be reduced below 4·5 or 2 with hydrogen peroxide alone, a combination of both sodium hypochlorite and hydrogen peroxide was attempted. The solution of seedlac in sodium bicarbonate was first partially bleached with sodium hypochlorite and then completed with hydrogen peroxide. Properties of the products obtained under varying amounts of hypochlorite and hydrogen peroxide are listed in table. No. 15 It will be evident that besides good colour comparable to hypochlorite bleached lac, the products have appreciable life and flow. It is noteworthy that chlorine contents of these bleached products are much lower than those of hypochlorite bleached lac.

TABLE 15 — PROPERTIES OF HYPOCHLORITE-PEROXIDE BLEACHED LAC

Sl No.	Amount (ml) of bleach liquor (3%) 100 g seedlac	Amount of hydrogen peroxide (10W/v) added (ml)	Temp. of bleaching (°t)	Time of bleaching (hr)	Yield (%)	Colour index	Life (minutes)	Flow (mm)	Acid value	Chlorine content (%)
			Rangeeni seedlac (Bleach Index 100) used							
1	333·0 (full)	Nil	26±2	24·0	91·0	0·26	5·0	19·0	9·0	1·5
2	250·0 (three-fourth)	150·0	26±2	30·0	90·0	0·31	23·0	32·0	76·2	0·61
3	167·0 (half)	150·0	26±2	30·0	90·0	0·5	36·0	38·0	74·5	0·47
4	83·5 (one-fourth)	150·0	26±2	30·0	90·5	1·33	38·0	44·0	76·8	0·42
			Rangeeni seedlac (Bleach Index 84) used							
5	140·0 (half)	100·0	24±2	30·0	89·0	0·35	45·0	44·0	68·0	—
6	140·0 (half)	150·0	24±2	30·0	91·0	0·31	46·0	46·0	70·3	—
7	140·0 (half)	200·0	24±2	30·0	90·0	0·24	46·0	48·0	71·3	—

(e) *Blocking of lac*

Some preliminary work on this problem was carried out but due to non-availability of requisite equipment of testing the work could not be carried out further.

2. Modification of shellac

(a) *Crafting of shellac with vinyl monomers*

The conditions for the hydroperoxidation of shellac and the grafting of vinyl monomers or their mixtures on its backbone have already been reported in the earlier annual reports (1964 to 1968). The work has once again been started at the end of the year. To start with, the hydroperoxidation methods both in aqueous and solvent media, as reported earlier, were repeated by passing oxygen gas through an ammoniacal or a methylethyl ketone solution of dewaxed lac. It has been noted that hydroperoxidation takes place more favourably in ketone solution than in aqueous medium.

(b) *Mechanism of reaction of lac with amino resins*

It was reported (*A. Rep.* 1968 & 1969) that when lac-butylated urea resin films (with or without catalyst) are baked at 150°C, a polycondensation type of reaction takes place between the carboxyl and hydroxyl of lac and methylol and butoxy groups of the urea resin.

Further studies were made to find out the effect of air drying on the degree of curing of lac/urea resin films. As such there was found no curing of the films in the cold, but when an acid was used as a catalyst the films cured and the degree of curing reached to 75-80 per cent. Of the various acids tried for curing, only *p*-toluene sulphonic acid amongst organic acids and hydrochloric, sulphuric and nitric acids amongst inorganic acids catalysed the curing process satisfactorily.

Addition of acids, however, reduced the shelf life of varnishes considerably. The precipitation and gelling tendency within a short period indicated that some chemical reaction takes place in the solution stage as well. The nature of this reaction was studied and it was found that after the addition of catalyst the acid value of the varnish slowly decreased indicating that the carboxyl group of lac slowly reacted with the methylol and/or butoxy groups of the urea resin.

With a view to further confirm the nature of the reaction of lac/urea resin on baking, aleuritic acid was taken in place of lac. The films obtained by this combination were baked under similar conditions and studied for carboxyl and hydroxyl values. It was found that both hydroxyl and carboxyl values slowly decreased as in the case of lac supporting the nature of the reaction interpreted earlier.

(c) *Modification of shellac with sulphuric acid*

Precipitation occurs when concentrated sulphuric acid is gradually added to a solution of lac in alcohol under certain conditions. The precipitates are modified lacs possessing properties different from those of the parent lac. The preparation of six such modified lacs and their physical properties and chemical constants and film properties of four of them were reported earlier (*A. Rep.* 1967, 1968 and 1969).

In order to find out the difference, if any, between the sulphuric acid modified lac and original lac, the former was hydrolysed and the properties of the hydrolysed product were studied and given below :

Appearance — Dark, brown, viscous and tacky
Yield — 80 per cent
Acid value — 181·0
Saponification value — 227·3
Hydroxyl value — 200·0
Molecular weight
(Rast) (average) — 301
Life under heat (150°C) — 205 minutes

It will be evident from above that except hydroxyl value, there is hardly any difference.

Next the nature of the modified lac and its methyl ester were studied by means of thin layer chromatography. In the developing solvent system, ethyl acetate : acetic acid (100 : 1), the modified lac gave 4 spots as against 6 for parent lac.

Methyl ester of hydrolysed lac acids were next run side by side, in trichloroethylene : chloroform : methanol (15 : 6 : 3) solvent system and 9 clear spots were noted having R_f values of 0·17, 0·20, 0·23, 0·45, 0·57, 0·63, 0·72, 0·78 and 0·88. This study further showed that there may not be any appreciable difference in the sulphuric acid modified lac and parent lac.

(d) *Modification of hydrolysed lac*

In order to modify total hydrolysed lac so as to increase its various practical applications, effect of heat at 150°, 175° and 200°C on its chemical constants were studied and reported last year. The rebuilt lac, obtained by heating at 150°C for 5-5½ hours, from ammoniacal solution gave baked films, having outstanding gloss and flexibility. This rebuilt lac has been termed ' Rebulac ' and due to its superior film properties in aqueous media, the film properties of pigmented (red oxide and titanium dioxide) varnishes were studied and are brought out in Table 16.

It will be found that the water resistance of these films when baked at 150°C for 30 minutes varied from 5 to 7 days which, however, improved remarkably (25-30 days) when baked at 200°C for 10 minutes. Scratch hardness of the baked films varied from 1500 to 1800 g.

Since Rebulac is sticky in nature the best way of its handling was as a 66 per cent solution in butyl alcohol which could be used for the preparation of aqueous varnishes as mentioned earlier.

Bleaching of Rebulac

Since the colour of Rebulac is very dark and light colour might be prefered in some of its uses, a bleached product was prepared by adopting the conventional method of bleaching of lac in aqueous medium with sodium hypochlorite. The bleached product (colour index 0·48) was obtained in an yield of 93·5 per cent and its acid, saponification and hydroxyl values, life and flow were 85, 210, 89, 42 minutes and 140 mm respectively. The film properties were also found to be as good as original Rebulac.

TABLE 16 — FILM PROPERTIES OF REBULAC IN AQUEOUS MEDIA

Properties	Shellac	Rebulac (unpigmented)			Rebulac pigmented with			
					Red oxide and baked at		Titanium dioxide and baked at	
		Air dried for 7 days	Baked at 150°C for 30 mts	Baked at 200°C for 10 mts	150°C 30 mts	200°C for 10 mts	150°C for 30 mts	200°C for 10 mts
Appearance	The dried films under these conditions cracked and flaked off the surface	Smooth and glossy	Glossy	Glossy	Smooth and glossy	Smooth and glossy	Smooth and glossy	Smooth and glossy
Scratch hardness	—	1000	1100	1500	1600	1600	1800	1800
Water resistance	—	1·5 hrs	2·0 hrs	3·5 hrs	5 days	25 days	7 days	730 days
Salt-Spray (in hrs)	—	—	—	—	48	7100	48	7100

Hydrolysed lac was next modified by heating in combination with different proportions of linseed oil fatty acids. In a typical case, when hydrolysed lac and linseed oil fatty acids were mixed in the ratio of 3 : 1, and heated at 150°C for 6-6½ hours, the resulting product had an acid value of 53 and was soluble in alcohols, ketones, esters, and aqueous ammonia. Its films from aqueous ammoniacal solution were glossy but tacky when air dried. Use of cobalt naphthenate as drier, however, removed this difficulty and hard tack free air dried films could be obtained. The aqueous varnishes on pigmentation with titanium dioxide or red oxide, in presence of cobalt naphthenate, gave very glossy and hard films at room temperature. The films had good adhesion and flexibility. The scratch hardness was more than 2000 g. The water resistance, however, was not very appreciable.

3. Study of the constitution of lac

As is well known, lac resin is composed of a number of components which are inter- and intra-esters of various aliphatic and terpenic polyhydroxy acids. Uptil now, by the application of various techniques such as alkaline hydrolysis, esterification and adsorption, thin layer (TLC) and gas liquid chromatography (GLC) etc., a number of these acid constituents have been isolated and characterised. Studies at present in progress include attempts to resolve the resin into individual components by TLC and precipitation methods, and the constituent acids of one (the ether soluble) fraction of lac, namely soft resin.

(a) *Separation and analysis of the components of lac resin*

The successful resolution of a sample of dewaxed decolourised lac by preparative layer chromatography into five components was reported last year.

These components were hydrolysed and the recovered constituent acids were converted into methyl esters. The mixture of methyl esters did not give good resolution into individual esters by thin layer chromatography.

With freshly activated silica gel plates, the resin was found to resolve in the solvent system ethyl acetate : acetic acid (100 : 1 : v/v), into eight fractions instead of five as reported earlier.

(b) *Molecular weight of lac and its fractions*

In the last annual report the determination of molecular weights of lac, soft resin, hard resin and fractions of hard resin by the vapour pressure osmometer method was reported. During the year under report the relationship between the molecular weight and intrinsic viscosity of hard resin and shellac was studied.

(a) *Intrinsic viscosity-molecular weight relationship of hard resin and its fractions*

Hard resin was fractionated into eleven fractions by dioxane-benzene at 30°C. The intrinsic viscosities of the fractions were determined in dioxane at 30°C by Ubbelhode dilution viscometer and their number average molecular weight by vapour pressure osmometer and reported last year. The values are given in Table 17. The log of $[\eta]$ of the eleven fractions and log of their number average molecular weights were plotted; and a straight line was obtained. From the slope and

intercept, the value of α and K was calculated. The following relationship was found :

$$[\eta] = 19{\cdot}95 \times 10^{-4}M^{0{\cdot}5} \text{ in dioxane at } 30°C.$$

TABLE 17

Fraction No.	% of polymer based on total	$[\eta]$ in dioxane at 30°C (dlg^{-1})	$\bar{M}\eta$ by osmometer	$\bar{M}v$ by viscosity
1	2·00	0·0555	780	773
2	2·128	0·0580	852	844
3	4·36	0·0665	1,072	1,110
4	7·24	0·0665	1,057	1,110
5	13·632	0·0695	1,140	1,213
6	9·516	0·0700	1,345	1,231
7	19·20	0·0715	1,415	1,284
8	12·68	0·0810	1,665	1,648
9	10·45	0·086	1,930	1,858
10	15·86	0·103	2,750	2,665
11	2·34	0·12	3,537	3,617

(b) *Intrinsic viscosity-molecular weight relationship of shellac and its fractions :*

In a similar way, dewaxed decolourised shellac was fractionated into thirteen fractions by dioxane-benzene at 30°C. The intrinsic viscosities and molecular weights of the fractions were determined and the values are given in Table 18. The relationship in this case was found to be

$$[n] = 7{\cdot}08 \times 10^{-4}M^{0{\cdot}65} \text{ in dioxane at } 30°C.$$

TABLE 18

Fraction No.	% of polymer based on total	$[\eta]$ in dioxane at 30°C (dlg^{-1})	$\bar{M}\eta$ by osmometer	$\bar{M}v$ by viscosity
1	11·66	0·036	438	421
2	3·53	0·055	725	809
3	3·26	0·055	727	809
4	4·24	0·0555	780	820
5	4·57	0·058	923	878
6	4·89	0·0575	900	866
7	6·14	0·0705	1,382	1,186
8	7·18	0·069	1,270	1,147
9	13·59	0·0745	1,394	1,290
10	10·56	0·0845	1,415	1,566
11	10·31	0·0795	1,601	1,430
12	8·56	0·098	2,089	1,967
13	9·26	0·121	not determined	2,721

(c) *Polymerisation of acetonated aleuritic acid*

The kinetics of polyesterification of isopropylidene derivative of aleuritic acid, and the solubility and precipitability properties of the polyesters were reported last year. The intrinsic viscosity-molecular weight relationship of the polyesters have now been established.

Polyesters prepared at 180 ± 1°C were taken for the study and the results are brought out in Table 19. The relationship of molecular weight versus intrinsic viscosity from samples of polyesters at serials 2, 4 and 6 was found to be as given below

$$[\eta] = 7{\cdot}943 \times 10^{-4} M^{0{\cdot}65}$$

Three more polyesters were prepared and molecular weights were calculated from this equation as well as from end group (Sl Nos. 1, 3, 5, columns 6 and 4) for comparison. The results were in good agreement.

TABLE 19

Sl No.	$[\eta]$ in dioxane at 30°C	Acid value	$\overline{M\eta}$ by titration	$\overline{M\eta}$ by osmometer	$\overline{M\eta}$ by viscosity
1	0·05	97·2	576·1	—	585·73
2	0·0585	67·3	832·1	743·71	745·77
3	0·072	48·0	1,166·0	—	1,026·4
4	0·091	36·1	1,551·0	1,609·9	1,476·4
5	0·11	27·7	2,022·0	—	1,990·0
6	0·147	20·0	2,800·0	3,110·0	3,078·2

(d) *Constitution of soft resin*

It was reported earlier (*A. Rep.* 1969) that 80 per cent of the constituent acids of soft resin had been isolated and characterised. During the period under report, attempts were made to isolate and characterise the remaining constituent acids. The unidentified fractions were pooled together, hydrolysed and again esterified with methanolic hydrogen chloride and the esterified material was extracted with ether, chloroform and ethyl acetate successively. The ether soluble fraction was the major one and was chromatographed over silica gel into a number of fractions. One of these fractions gave a pure ester melting at 71-71·5°C and the recovered acid melted at 93·5-94°C. It was found to be identical with the isomer of aleuritic acid isolated earlier. Another two of the fractions afforded two pure acids which were identified as *threo*-9, 10-dihydroxymyristic and 10, 16-dihydroxypalmitic acid by the help of thin layer chromatography and oxidative degradations.

Chloroform and ethyl acetate extracted fractions yielded terpenic esters by repeated fractionation on silica gel from which shellolic, epishellolic, lakshólic, epilaksholic and jalaric acids were isolated and identified. In addition to 80 per cent reported earlier approximately another 10 per cent of constituent acid of the soft resin were thus isolated and characterised and the various acids and their proportion in soft resin are listed in Table 20.

TABLE 20

Sl No.	Acid present	Percentage
1	Saturated and unsaturated non-hydroxy acids	1·3
2	6-Ketomyristic	2·5
3	6-Hydroxymyristic	9·3
4	16-Hydroxypalmitic	2·0
5	16-Hydroxypalmitolic	1·0
6	*threo*-9,10-Dihydroxymyristic	13·2
7	10,16-Dihydroxypalmitic	2·0
8	Aleuritic	14·0
9	Isoaleuritic	2·3
10	Shellolic and epishellolic — 6·5%	40·6
11	Laksholic and epilaksholic — 4·1%	
12	Jalaric — 30%	—
13	Unidentified	—
	(i) m.p. 83-84	0·3
	(ii) liquid dihydroxy	2·0
	Total	90·5

4. Electrical properties of modified lacs

(i) *Dielectric properties of lac-amino resin blends*

Amino resins have been shown to be valuable additives to shellac to improve heat and water resistance of its films. Melamine and urea resins were particularly suitable because the improvements were produced even in air dried films. These films showed improved electrical properties (*A. Rep.* 1968). It was reported earlier that the breakdown voltage of films (2280 volts/mil) from varnish containing 60 parts of dewaxed shellac and 40 parts of butylated melamine resin was about 3 times that of parent lac films (800 volts/mil).

Similar studies were extended to lac-urea resin blends. In this case also the maximum of 2130 volts/mil at 25°C was obtained for the varnish containing 60 parts of lac and 40 parts of urea resin. The comparative dielectric properties of lac-melamine and lac-urea resins and their test results as per ASTM (D 115/1955) are brought out in Tables 21 and 22.

TABLE 21 — DIELECTRIC STRENGTH (IN KV/MIL) OF FILMS OF SHELLAC AMINO RESIN BLENDS

Conditioning and testing procedure	Shellac/ melamine resin	Shellac/ urea resin
Baked films, conditioned at 95°C for 2 hrs and tested at 25°C	2·17	2·13
Baked films, conditioned at 95°C for 2 hrs and tested at 90°C	2·10	2·00
Baked films, conditioned at 95% RH for 24 hrs and tested at 25°C	1·04	1·54
Airdried films, conditioned at 0% RH for 24 hrs and tested at 25°C	1·31	1·30
Airdried films, conditioned at 100% RH for 24 hrs and tested at 25°C	0·52	0·30

TABLE 22 — COMPARISON OF THE PROPERTIES OF SHELLAC/MELAMINE AND SHELLAC/UREA RESIN BLENDS

Properties	Shellac/ melamine resin blend	Shellac/ urea resin blend
1. Solid content	32·5	40·00
2. Specific gravity at 25°C	0·93	0·95
3. Viscosity (centipoises)	26·1	25·6
4. Draining (%)	50-60	120
5. Heat flexibility (hrs)	24	24
6. Time of drying (minutes)	30 (baked) 30 (air dried)	30 (baked) 120 (air dried)
7. Oil resistance	good	good
8. Dielectric strength (kV/mil)	2·25	1·65

It will be seen from the above tables, that there are hardly any significant differences between the two resin blends except that films from lac-urea resin blend take sufficient time (120 minutes) for air drying than the other (30 minutes).

Curing of blends

The breakdown strengths of lac-melamine resin films were found to increase with the time of cold curing and reached a maximum (2·2 kV/mil) after 3 days of curing. This was in confirmation with the earlier finding that the best film properties of such a blend were obtained only after 3 days of preparation of the blend (*A. Rep.* 1969). Further the break down strengths of a mixture of shellac or *p*-toluene sulphonic acid and melamine resin were found to be the same (2·2 kV/mil). This indicated that shellac, being acidic, acts as a catalyst for curing of melamine resin.

Moulded insulators

The lac-melamine resin combination was recovered from the varnish blend and was moulded into discs at 120°C under 10,000 lbs/sq inch pressure. The BDV of these discs of varying thicknesses were determined and the results were found to obey the empirial law

$V = At^n$, where V = BDV in kV, A and n are constants and t = thickness. The material having higher values for 'n' is supposed to be a better dielectric. This value for shellac and for the blend were 0·54 and 0·69 respectively indicating that the latter is a better insulator and possesses higher corona resistance.

(ii) *Dielectric properties of lac-rubber combinations*

The incorporation of shellac or modified lac into natural and synthetic rubbers has been found to serve as a processing aid as well as improving modulus, tensile strength, tear resistance and hardness of the rubber. The effect of this incorporation of lac on the electric properties of rubber was now studied.

Some preliminary work with lac-natural rubber combinations in presence of CBS (cyclohexyl benzthiazyl sulphenamide) accelerator had shown that the dielectric loss of these stocks decreased with the increase of lac content and at 10 per

cent lac content the loss was the minimum. The dielectric constant also decreased from 3·75 to 3·15 kV/mil with the increase of lac content up to 10 per cent.

5. Depolymerisation of polymerised lac

Shellac looses its solubility in alcohol on heat treatments, storage or exposure to hydrogen chloride gas. Such insoluble shellac can be resolubilised by boiling with a solvent containing hydrochloric acid or by autoclaving in presence of water at 20 atmospheric pressure. In order to find out the optimum conditions for such resolubilisation by the former method a detailed study was undertaken.

Shellac was polymerised at 150°C for 1, 2 and 3 hours and the polymer samples I, II and III were subjected to acid hydrolysis in alcohol medium at water bath temperature. The degree of dissolution was followed by estimating the amount of polymer left undissolved at a given time. The degree of dissolution for polymer III approached the maximum value of 98·64 per cent when the hydrochloric acid concentration was 6·27 per cent (w/v). It was also found that water accelerated the rate of dissolution up to a certain concentration beyond which it had a retarding influence. The rate of dissolution of polymer II was found to be maximum when the concentration of water was 8·81 g/100 ml of alcohol.

The rate of dissolution was also found to be dependant on the concentration of the polymer being hydrolysed. The maximum value of 99·62 per cent was obtained when the polymer concentration was 1 per cent which remained almost constant up to 3 per cent polymer concentration. The value decreased to 97·36 per cent when the polymer concentration was increased to 6·97 per cent.

6. Determination of shellac in presence of other resins

It was reported last year that reproducible results in the determination of shellac by urea-complex formation could not be obtained. The work was continued this year also but reproducible results were not obtained. Hence the work has been kept in abeyance.

7. Water thinned polish for wood

(a) Last year it was reported that the modification of ammoniated lac with water soluble urea and maleic resin served as a satisfactory water based composition for polishing wooden furniture. With a view to study the performance of forced dried films with different percentages of urea resin, films were baked at different temperatures. Film performance of the varnish containing 20 per cent urea resin was found to be the best when baked at 150°C for 30 minutes. It gave improved heat, water, alkali, acid, acetone and alcohol resistance as well as scratch hardness.

Acceleration of the curing process was also studied by exposing the film to sunlight for 8 hours and also baking at 65°C for 1 hour. It was observed that both these processes improved the film performance to a considerable extent but baking at 150°C for 30 minutes was the best.

For improving the storage stability of the water thinned wood polish developed earlier, addition of 10 per cent alcohol on the weight of varnish was tried. It was noted that the addition of alcohol not only increased the storage stability

of the varnish but also enhanced the gloss of the film and checked the frothing of the varnish during agitation.

Since melamine resins are better curing agents than urea resins, attempts were made to modify the aqueous lac varnish with water soluble hexamethylol and hexa-kis methoxy-methylol melamine resins. The above resins were prepared in the laboratory by the standard methods, and when these resins were blended with aqueous lac varnish some precipitation was noticed showing thereby incompatibility of these resins with lac. Further experiments are being made to prepare melamine resin which could combine with lac varnish and give better performance.

(b) The above aqueous wood finishing composition is difficult for transportation due to its bulkiness. Hence attempts were made to develop a water soluble solid composition which can be readily converted to aqueous polish at site.

As a result of systematic studies, a solid composition was developed by exposing a mixture of dewaxed lac and maleic resin (80 : 2) to ammonia vapour which could be easily dissolved in water. Addition of 15 per cent commercial isopropanol and 15 per cent maleinised linseed oil to this composition was found to further improve the performance of the varnish.

This aqueous varnish could satisfactorily be applied by French polishing technique to produce a hard, smooth, and glossy finish on wood. No tackiness of film could be noticed. Air dried films of this composition showed water resistance up to one hour and heat resistance up to 90°C. In general this composition compared with the conventional spirit based French polish in performance.

8. Shellac rubber combinations

(a) *Incorporation of shellac in rubber*

A study of the effects of incorporation of shellac into natural rubber was carried out last year using CBS (cyclohexyl benzthiazyl sulphenamide) as the accelerator. This year the study was continued without the addition of sulphur and making use of TMTD (tetramethylthiuram disulphide) as the accelerator. The properties obtained using various curing systems with varying proportions of shellac are summarised in Table 23.

The following conclusions can be drawn from the data given in Table 23, that shellac

i) acts as a processing aid with all the three curing systems tested and helps in the incorporation of various rubber compounding ingredients.

ii) exerts a useful anti-scorching effect with two accelerators namely MBT and CBS

iii) enhances modulus when CBS or TMTD is the accelerator

iv) increases tear strength with MBT

v) at a lower concentration (2·5 parts/100 parts rubber), raises tensile strength, hardness and impact resilience when CBS is the accelerator.

(b) *Mechanism of interaction of shellac on incorporation with rubber*

Last year the mechanism of interaction of shellac on incorporation into natural rubber using MBT (mercapto benzothiozole) as the accelerator was reported. This

TABLE 23 — EFFECT OF INCORPORATION OF SHELLAC ON THE PROPERTIES OF NATURAL RUBBER USING DIFFERENT CURING SYSTEMS

(Base mix: Natural rubber, 100; zinc oxide, 4; stearic acid, 1; *PBN, 1 part)

Shellac added parts/100 parts rubber	Optimum cure time at 140°C min	Mooney No. (ML +4 at 120°C)	Scorch time min-sec	Modulus at 200% kg/cm²	Ultimate elongation %	Tensile strength kg/cm²	Tear resist. kg/cm	Durometer hardness	Impact resilience
Sulphur, 2·5; MBT, 0·5 part									
0·0	30	19·0	Less than 4 min	8·4	800	139·4	33·8	37	76·2
2·5	30	18·5	6-40	8·0	780	125·1	36·9	37	72·5
5·0	30	18·0	9-50	7·7	750	112·8	36·0	36	63·5
7·5	40	17·0	13·0	6·4	730	100·0	35·5	36	61·8
10·0	45	16·5	17-4	5·9	700	85·7	34·7	36	58·5
Sulphur, 2·5; CBS, 0·5 part									
0·0	20	18·5	10-16	9·9	750	141·7	37·4	35	76·2
2·5	20	18·0	12-2	12·5	700	144·6	35·8	38	79·9
5·0	30	17·5	14-5	10·7	650	132·1	35·7	31	70·7
7·5	30	17·5	16-35	10·7	630	122·4	35·8	31	68·9
10·0	30	17·0	19-35	11·1	600	110·2	35·9	31	67·0
Sulphur, nil; TMTD, 2·5 parts									
0·0	20	18·8	10-48	12·1	600	150·0	30·9	35	78·9
2·5	30	18·5	10-25	12·4	600	121·5	30·6	30	74·3
5·0	30	18·5	10-0	12·3	580	110·2	30·4	31	72·5
7·5	30	18·2	9-40	12·3	550	100·1	30·3	31	70·7
10·0	30	18·0	9-1	12·1	500	88·7	30·1	31	68·9

*Phenyl *b*-naphthylamine(antioxidants)

year the work was continued using CBS (cyclohexyl benzthiazyl sulphenamide) as the accelerator. The compostion of the base mix was as follows :

Natural rubber	— 100	parts
Zinz oxide	— 4	,,
Stearic acid	— 1	part
PBN	— 1	,,
Sulphur	— 2·5	parts
CBS	— 0·5	,,

Shellac was added at concentrations of 0·0, 2·5, 5·0, 7·50 and 10·0 parts. The vulcanisation was carried out at 140°C and 4000 lbs/□ pressure for three different periods of 15, 20 and 30 minutes for the control and 20, 30 and 40 minutes for other samples.

(i) *Free sulphur content*

Free sulphur contents increased the progressive addition of shellac but decreased when the vulcanisation period was prolonged. A near constant value was obtained after a period of 30 minutes of vulcanisation.

(ii) *Measurement of cross link density*

Cross link density was determined by swelling rubber samples in benzene till the equilibrium was reached and calculated using Flory-Rehner equation. It was found that the cross link density decreased by the addition of shellac. As the time of vulcanisation was increased, the cross link density also increased and assumed a near constant value after a period of 30 minutes of vulcanisation.

9. Lac and lac derivatives as modifiers for phenolic resins for plastics

Due to shortage of staff the work was not continued this year.

10. Use of lac and modified lacs in surface coatings

(a) *Shellac emulsions*

The use of water thinned coating is increasing day by day due to the various advantages of water as a thinner. These compositions are based either on water soluble resin or on binders emulsified in water. Shellac is a water soluble resin but modification of shellac such as those produced by incorporation of oils etc. are not always water "soluble". For water thinned coatings they have to be used in emulsion form.

i) Shellac emulsion paints based on shellac, rosin, castor oil and zinc oxide had been formulated by the Shellac Export Promotion Council, Calcutta and is understood to be in commercial production in limited quantities. The product, however, does not appear to have made much headway presumably due to the the high proportion of rosin present. The possibility of formulating alternate shellac emulsions and paints was, therefore, investigated.

Shellac drying oil combinations have been developed earlier in this Institute and elsewhere in a variety of ways. Therefore, to start with the following typical compositions were studied for emulsification.

Composition No.	Materials	Parts by weight
I	Linseed oil	100
	Litharge	6
	Lime	3
	Shellac	50
II	Linseed oil	100
	Litharge	3
	Lime	1·5
	Shellac	50
III	Linseed oil	100
	Glycerol	15
	Litharge	0·5
	Shellac	55
IV	Linseed oil	100
	Glycerol	10
	Litharge	1
	Shellac	55
V	Linseed oil	100
	Lime	2·5
	Shellac	50
VI	Linseed oil (double boiled)	100
	Glycerol	20
	Shellac	60

The above compositions were first dissolved in white spirit and requisite amount of an emulsifier such as triethanol oleate, Jardinal, Sulphotan, Noigen and Calsoline oil was added. The emulsification was then obtained by vigorously stirring the above mass and adding gradually water containing various proportions of ammonia (0-10 percent). As a result of series of experiments, it was found that only compositions II and V produced satisfactory emulsions and could be diluted with large amount of water without breaking. With 0·5 percent of cobalt naphthenate as drier and diluted to 25 percent solids, these emulsions produced on air drying smooth and homogenous films which, however, were a little tacky.

These emulsions could be pigmented by the incorporation of the requisite quantity of aqueous pigment paste of titanium dioxide. Films on glass or tin plate air dried to a matt finish of reasonable hardness (500 g), water resistance and good flexibility. Films baked at 150°C for 30 minutes were hard (900 g). Application of the emulsions on cemented block or on a wall, however, did not give smooth and dried films presumably due to breaking of the emulsions.

(ii) *Semi-synthetic shellac emulsion*:

The recent world trend is fast changing over to the use of water as solvent/ thinner for organic coatings. Development of water soluble/dispersible synthetic resins has given great impetus to this new approach.

Like most of the water soluble organic coatings, though aqueous shellac varnishes also form films, these do not possess adequate resistance to water and solvent etc. unless baked. To achieve this the use of modified shellac is indicated.

Several modifications were tried out but not with much success. Recently a semi-synthetic shellac emulsion based on lac and melamine resin was developed which showed good storage stability. This emulsion gave clear and transparent films on air drying which were highly resistant to water for days together and had good flexibility and hardness.

In view of excellent water resistance of air dried films this emulsion appears to have very promising future as:

i) water resistant coating material,
ii) vehicle for emulsion paints used for internal decoration of houses and
iii) media for water proof inks.

(b) *Electrodeposition of shellac varnishes, primers and paints*

Electrodeposition, also known as electrocoating, anodic coating etc., is the most recent technique for the application of paints and varnishes to conducting surfaces. A systematic study of the possibilities of shellac for use as the vehicle for the formulation of such paints and varnishes has been under investigation since 1967.

A satisfactory coating composition based on shellac (100 g), triethanolamine (25 ml) and red oxide (100 g) had been developed for the purpose. The optimum electrical requirements has also been determined (*A. Rep.* 1968). Further it was reported last year that phosphated panels were more corrosion resistant than untreated panels and that *p*H and specific conductivities of different pigmented and unpigmented varnishes increased with rise of temperature.

During the year under report, the effect on hydrogen ion concentrations (*p*H-value) and specific conductivities, on storage of unpigmented and pigmented varnishes were determined. It was observed that *p*H decreased on storage. This may be due to the hydrolysis of salts of shellac or modified shellac. In the case of shellac/epoxy combined product or partly esterified lac, no change was observed. The specific conductivity, which measures the resistivity and also indicates the insulating property of the film deposit, did not show any change when these varnishes were stored for four months. It was also observed that red oxide pigment had no effect on specific conductivities.

Improvement in throwing power, both in area and weight per cent was noticed with the increase of proportion of binder in the primer but there was a decrease in total deposit. A deposition period of 2 minutes was found sufficient for plain surface while surface of intricate shaped material required, 3 to 4 minutes depending upon the nature and proportion of the binder used. Dilution of the primer upto 10 per cent solid content showed good throwing power but on further dilution it was poor. Of all the formulated primers, shellac/ maleinised oil based

primer showed relatively better throwing power while shellac/epoxy based one gave poor result.

The percentage of pigment/binder in the electrophoretically deposited films were analysed. The deposited films were first washed thoroughly and then taken out from the surface of the panel. Films were deposited at different temperatures (25°-40°C), deposition periods (60-180 seconds) and also solid concentrations of the system. In addition, films were also collected from different pigment/binder ratio. Those were shellac based primer, shellac/epoxy, shellac/alkyd, shellac/ moleinised oil and partly esterified lac based primers. From the analyses of the deposits it was found that 10-15 per cent (on the total weight of both solid) of the pigment present in the deposit was higher than primer but this percentage was only 4-6 per cent in the case of shellac/epoxy based primer.

(c) *Modification of lac with epoxy resins*

Modification of lac with epoxy resin by fusion at 150°C for 15 to 20 minutes. Films from the fused products gave excellent performance after baking (*A. Rep.* 1964-65, 16). Since the technique of fusion is not suitable for large scale production, studies were undetraken last year to carry out the combination, in a solvent system, with or without catalyst. The most satisfactory solvent system reported was butanol: xylene in the ratio of 1:1 or 1:2 and the baked films from the reaction products, obtained by refluxing for 2 to 10 hours, were hard, flexible and resistant to chemicals and solvents. The film properties could be further improved by the addition of dicyandiamide (*A. Rep.* 1969).

i) The effect of catalysts (1-2% on the weight of solids) such as dicyandiamide, maleic anhydride and *p*-toluene sulphonic acid, on the combination of shellac (100 parts) and epoxy resin (epikote 1001, 40 parts) at reflux temperature in butanol: xylene (1:1) solution were studied this year.

With dicyandiamide gelation occured in about 2 hours refluxing and it was considered that for better performance the reaction should be carried out for 90 minutes in presence of 1·5 per cent of the catalyst. The solid product thus obtained had an acid value of 33·5 and its films from solvent were hard (1600 g), glossy and resistant to chemicals and solvents.

With maleic anhydride and *p*-toluene sulphonic acid, however, there were no gelling even after 8 hours of refluxing. The resulting products had acid values of 38·5 and 39·8 respectively. Baked films (150°C for 30 minutes) from aqueous ammoniacal varnishes or emulsions were smooth, hard, flexible and resistant to water, mild alkalies and acids but not so glossy. These compositions were also found suitable for water based red oxide primers.

(ii) Attempts were also made to react shellac with low molecular weight epoxy resin (epikote 834, mol-wt. 450). The product, obtained with 20 per cent of epoxy resin on the weight of lac under the above conditions in absence of catalyst, gave baked films which are also hard, glossy, flexible and resistant to water, 95 per cent spirit, mild acids and alkalies.

(d) *Studies on water based red oxide primers*

Last year the production of a satisfactory anticorrosive baking type primer based on dewaxed lac, maleinised, linseed oil, red oxide and other pigments and

their mixtures was reported. In this process, the removal of excess maleic acid in the preparation of maleinised linseed oil was avoided by taking the requisite amount of maleic acid for the combination.

Further experiments were carried out to find out the optimum proportion of different pigments and to standardise the manufacturing process. As a result the following composition was found to be the most satisfactory.

Aqueous lac-maleinised linseed oil varnish (25 percent solids) containing 90 parts dewaxed lac and 10 parts maleinised oil	100 g
Red oxide	75 g
Mica (wet ground)	25 g
Talc	5 g

Baked films from the above primer composition (on mild steel) were hard, smooth and matt with good adhesion and withstood exposure to corrosion in a salt spray cabinet for 100 hours.

(e) *Solvent release of shellac films*

As is well known, films of shellac produced from its varnish in alcohol retain minute proportions of the solvent for a considerable time which naturally affect the properties of the films. It is also known that solvent release can be accelerated or retarded by using other solvents along with alcohol. A systematic study to investigate conditions for the most rapid release of the solvent, used alone or in admixture, from such films will thus be of much practical importance. Such a study was taken up in 1968. The extent of solvent release was determined by estimating the ethoxyl content of the film from time to time. Last year the retention of solvent with time from films prepared with 40 per cent solution of dewaxed decolourised lac and exposed at 40°C or stored at room temperature was reported. During the year under report, the retention of solvent from films of dewaxed lemon shellac under similar conditions as above was studied. The films were found to dry to a constant ethoxyl content of 0·52 and 1·12 per cent in 44 days at 40°C and 50 days at room temperature respectively.

(f) *Lac-oil combinations modified with melamine resins*

Enamel paints based on alkyd/amino resin combination are very widely used for coating of refrigerations, car bodies, industrial equipment etc. Since lac oil combinations also resemble with alkyds and therefore experiments were made to develop satisfactory enamel paints based on lac oil and amino resin combination.

Lac-linseed oil compositions were prepared by the standard (a) glyceride and (b) calcium oxide methods. Films prepared from compositions obtained by method (a) remained tacky for several days while those by method (b) dried quickly. Addition of cobalt naphthenate as drier (0·02 per cent) though reduced the drying time, tackiness could not be removed before two weeks.

Both the samples after baking at 150°C for 1 hour, however, gave non-tacky films resistant to water and solvents.

Modification of lac/linseed oil/glycerol and lac/calcium oxide/linseed oil compositions by adding butylated melamine formaldehyde resin was next tried. Addi-

tion of melamine resin (40 per cent on solid basis) to the lac-oil compositions and in presence of drier only gave films from white spirit on different substrates which became tack free after 6 days of air drying. The films were hard and resistant to solvents, but not to water. Addition of *p*-toluene sulphonic acid (5 per cent) in the above composition, however, improved the tackiness of the films as well as the hardness, solvent and water resistance.

The above blends on pigmentation and application on different substrates gave hard, smooth, highly glossy as well as solvent and water resistant films after seven days of air drying.

(g) *Application techniques of French polish*

(i) French polishing is a time consuming as well as a costly technique. The gloss and the smoothness obtained by this technique also do not compare with the finish obtained by spraying of lacquers. Since the latter technique is economical and also cheap, attempts were made to develop a satisfactory composition of sprayable varnish which may produce a hard, smooth and glossy finish.

As a result of systematic study a satisfactory composition of sprayable varnish was developed by dissolving lac in a mixture of alcohol, toluene and butanol in the ratio of 2: 1: 0·15. This varnish could be sprayed satisfactorily to give smooth and glossy finish.

(ii) *A spiritless French Polish for wooden furniture*

Spirit solution of shellac is the most common form in which lac is used in the field of French polishing, metal lacquering, printing inks etc. The acute shortage of spirit at the moment in the country has badly affected the above trades. Alternate cheap solvents and solvent mixtures were therefore examined.

Recently National Organic Chemical Industries Limited, Bombay, brought out in the market three commercial solvents which are mixtures of isopropanol, water and acetone. All these solvents are cheaper than spirit and, therefore these were thoroughly studied as substitute for spirit. It was found that all the three solvents dissolved lac freely and gave clear varnishes. The resultant varnishes produced smooth, glossy, clear and transparent films whose properties, such as scratch hardness, flexibility, water resistance, heat resistance etc., compared favourably with the conventional spirit based shellac varnishes. For the purpose of French polishing isopropanol containing water (10%) served the best, and may be used in place of methylated spirit.

These solvents also dissolved most of the synthetic resins such as urea formaldehyde, Novolacs, epoxy (1001), maleic (spirit soluble) etc. and the solutions so obtained were found compatible with shellac varnishes.

The solvent, isopropanol containing water (10%), was also found to serve satisfactorily for the preparation of Melfolac (the heat, water and lacquer proof shellac finish) and tin plate lacquer developed earlier.

11. Use of lac and modified lacs as binder for jute fabric

(a) *Teachests from jute fabric*

Normally plywood is used for making teachests. While these come in contact with water or are exposed to humid atmosphere, the plywood tends to loose

their strength due to loss of adhesiveness of the binding material. The Indian Jute Industries Research Association (IJIRA) approached us to investigate the possibilities of preparing jute lac boards suitable for use in place of plywood for teachests.

Accordingly the study was initiated and as the material has necessarily to be cheap, only water based compositions for impregnation of hessian were attempted. The best result was obtained when hessian was soaked in an ammoniacal solution of *kirilac*, treated with dilute sulphuric acid to precipitate the lac on the fibres, washed with water to remove sulphuric acid, dried and pressed at 130°-140°C under 10,000 lbs/sq. in. pressure. Two-ply and three-ply boards prepared as above were very hard as well as water resistant and the three-ply ones were found by the IJIRA to be the most suitable for teachests. Three-ply boards of 40"×20" size were pressed at the Indian Mica and Micanite Factory, Jhumri Tilaiya and sent to the Association for practical trials.

(b) *Hard boards from wood pulp*

The Assam Hard Board Limited expressed their desire to find out the suitability of shellac as binder in place of phenolformaldehyde resin for the preparation of hard boards from wood pulp. Accordingly wood or bamboo pulp was impregnated with aqueous shellac solution in triethanolamine alone or in admixture with water soluble phenol-formaldehyde resin. The impregnated pulp after drying was pressed at 120°-140°C under 10,000 lbs/sq. in. pressure. The boards were hard and contained nearly 15 per cent of resin. Improved water resistance was observed only when a mixture of shellac and phenol-formaldehyde resin was used for impregnation. Samples were sent to the firm for evaluation of properties.

12. Use of lac for coating urea fertilizer

Studies had been initiated to investigate the suitability of shellac for coating urea fertilizer in order to reduce the hygroscopicity, caking tendency and leaching rate in the soil. A composition based on lac and linseed oil was developed to coat urea granules (*A. Rep.* 1968) and some agronomical studies were conducted and results reported last year (*A. Rep.* 1969).

During the year under report more agronomical studies were conducted.

(a) *Spinach crop*

Six treatments using nitrogen at three levels, namely 90 lbs, 135 lbs, 180 lbs and coated urea per acre, with three replications were studied in microplots of randomised block design at the Institute. The yield and nitrogen contents of the spinach plants did not indicate any appreciable difference between the coated and uncoated urea.

(b) *Wheat, maize and paddy*

As reported last year, agronomical studies on three crops were repeated at the Agricultural College, Kanke. Yield data for wheat and maize did not show any remarkable difference between coated and uncoated urea treatments. Data of grain yield of paddy crop are not available yet.

(c) *Jute*

Studies on *Corchorus olitorius* jute crop (variety JBO 632) were repeated at the Jute Agricultural Research Institute, Barrackpore for the second year. There were thirteen treatments and urea was applied by basal and top-dressing methods and at two nitrogen levels.

Data from fibre weight (Table 24) will indicate that when urea is used as fertilizer and one has to make basal application, coated urea is definitely better than uncoated urea.

TABLE 24 — COMPARATIVE EFFECT OF COATED & UNCOATED UREA ON JUTE (JRO-632) FIBRE WEIGHT (q/ha)— DATA

Sl. No.	Treatments	Fibre yield (q/ha)
1	Coated urea N-40 — Basal	22·53
2	,, ,, ,, — Top Dressing	26·96
3	,, ,, N-80 — Basal	22·89
4	,, ,, ,, — Top Dressing	27·81
5	Uncoated urea N-40— Basal	19·57
6	,, ,, ,, — Top Dressing	26·87
7	,, ,, N-80— Basal	19·71
8	,, ,, ,, — Top Dressing	28·60
9	Ammon. sulph N-40 — Basal	23·15
10	,, ,, ,, — Top Dressing	24·55
11	,, ,, N-80— Basal	28·46
12	,, ,, ,, — Top Dressing	29·40
13	Control (Mean)	16·33

Ammonification studies

Ammonification studies with lac-oil coated urea were conducted in the soil at 400 ppm urea N-level at room temperature for 8 weeks. It was found that the NH_3-N increased upto 4 weeks and thereafter decreased in the case of uncoated urea while increased upto 8 weeks in the case of coated one. There was an abrupt increase in the N level in the latter case after 8th week presumably due to the bursting of the coating. These studies have shown that the rate of hydrolysis in the soil of coated urea is slower than uncoated one.

New coating technique

It will be evident from above and earlier report that it is necessary to develop a better type of coated urea fertilizer having lower dissolution rate. In order to achieve this a new coating technique was developed. In this method urea granules were first given, under tumbling, preliminary coating with linseed oil (2%) followed by fine shellac powder (15%) and a conditioning agent (2%), such as soap stone or kieselguhr. The temperature of the mass was then raised to 100°C so as to melt the lac particles and give a uniform coating. Finally a coating of wax (5%) was applied at 60°C and a uniformly coated urea fertilizer was obtained. This coated urea was found superior to the earlier lac-linseed oil coated one in respect of dissolution rate, (84% as against 100% for the latter).

A double coating by the above new technique brought down the dissolution rate to 55 per cent. The evaluation of this product is underway.

13. Lac and modified lacs in adhesives

Last year, work on the adhesive property of different kinds of lac (*Kusmi*, *Rangeeni* and dewaxed) on steel to steel surfaces was reported. During the year under report, the work was continued with brass and copper surfaces following the same procedure adopted for steel panels. The highest bond strength on brass (0·23 ton) and copper (0·25 ton) was obtained with *Rangeeni* shellac by pressing at 150°C under 2000 lbs/sq. in. pressure for 2·5 hours. *Kusmi* shellac had maximum bend strength (0·18 ton) at 175°C for brass surface and at 200°C for copper surface (0·20 ton). Dewaxed lac under the same conditions had maximum bond strength at 175°C for brass surface (0·20 ton) and at 200°C for copper surface (0·22 ton).

The experiments were repeated varying the temperature, time and pressure and the best bond strength under various conditions were found out. The results thus obtained for iron, brass and copper surfaces are brought out in Table 25. It will be evident from the table that the bond strength of different metals are in the order of iron, brass and copper and the performance of various shellacs are in the order of dewaxed lac (DL), *Rangeeni* and *Kusmi*.

TABLE 25 — BOND STRENGTH OF DIFFERENT LACS

Surface	Lac taken	Maximum strength obtained in ton/ sq. in.	Temp. in °C	Pressure in lbs/ sq. in.	Time in hour
Iron	*Kusmi*	0·262	185	2000	2·5
	Rangeeni	0·320	200	400	2·5
	Dewaxed	0·350	185	400	1·0
Brass	*Kusmi*	0·210	175	2000	1·5
	Rangeeni	0·230	150	2000	2·5
	Dewaxed	0·250	175	800	1·0
Copper	*Kusmi*	0·210	200	1600	1·0
	Rangeeni	0·235	150	2000	2·5
	Dewaxed	0·240	200	2000	1·0

14. Adhoc Researches

(a) *Solvents for shellac*

This study was undertaken to find out a suitable solvent which could dissolve shellac in the minimum possible time without swelling. Such a solvent is in great demand for cleaning the surfaces and sides of printing rollers after use with shellac based inks.

Since there is no single solvent which can serve the purpose, mixture of solvents were tried. Powdered shellac (30 mesh) was dissolved in the mixture of various solvents to give a 10, 20 and 30 per cent solution (w/v) by vigorous shaking. The time taken for complete dissoution and the swelling, if any, were noted.

In order to see the effect of the solvents on the printing rollers which are made of rubber, known weight of rubber was immersed for different periods (30 to 18 hours) in the solvent mixtures and the increase in weight determined. The quickest dissolving solvent mixtures are brought in Table 26. Of these mixtures, 3 and 6 had the least action on rubber.

(b) *Effect of mixed solvents on film properties of lac*

Shellac is an excellent film former. The properties of the film produced from shellac varnishes however depend to a very great extent on the solvent and the experimental conditions such as humidity, temperature etc.

As it is known that mixed solvents serve better than any single solvent for the preparation of varnish, this study was undertaken to find out the best mixed solvent for the purpose and also to ascertain the adequate drying period of the film from any particular solvent.

Solutions of dewaxed lac (25% w/v) in the following solvent mixtures were prepared:

(1) Denatured spirit (95%) : acetone	(2 : 3)
(2) Methanol : acetone	(3 : 2)
(3) Spirit : toluene	(2 : 1)
(4) Methanol : spirit	(1 : 1)
(5) Ethyl acetate : spirit	(3 : 2)
(6) Ethyl acetate : spirit : toluene	(4 : 5 : 6)
(7) Spirit : butyl acetate	(3 : 1)
(8) Spirit (95%) as control.	

One set of films on glass and steel panels was allowed to air dry for seven days and the other set was baked at 150°C for 60 minutes.

Film properties of both air dried and baked films indicated that mixed solvents performed better as regards water and alkali resistance.

(c) *A new viscometer for determining the viscosity of convertible coating*

The trend of modern researches is oriented towards the development of chemically drying type of coatings which when applied in the form of thin layers turn into insoluble, infusible and chemical resistant films with good durability. Actually during film formation a macromolecule is formed by the condensation of low molecular weight resins present in the varnish. This condensation reaction proceeds in the solution stage as well but in this stage it is very slow.

Normally catalysed varnishes have poor shelf life owning to the above fact. For a single pack system it is necessary that the varnish should stand in a good condition upto about a year.

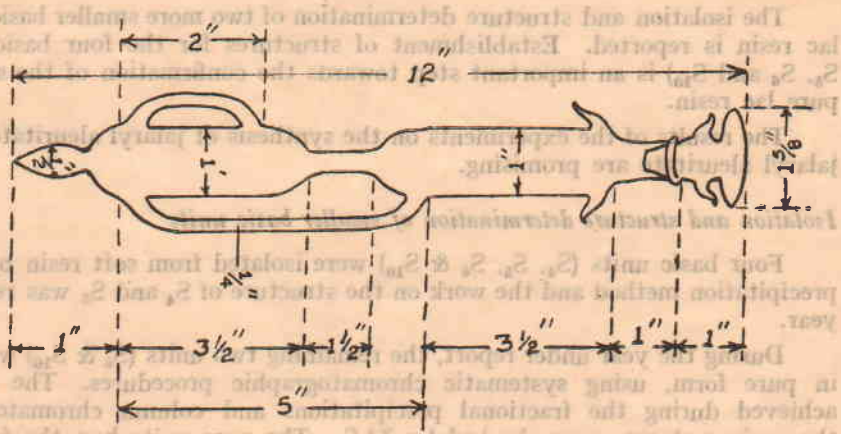
Shelf life or storage stability of such varnishes is normally determined by noting the extent of thickening or gelling of the varnish with time.

TABLE 26 — COMPARATIVE SOLUBILITY OF SHELLAC IN DIFFERENT SOLVENT SYSTEMS

Sl. No.	Solvent	Ratio of solvents (v/v)	Time of dissolution of lac (minutes)			Percentage increase in wt. of rubber on immersion in the solvent mixture		Remarks
			10 g	20 g	30 g	30 minutes	18 hours	
1.	Spirit + Trichloroethylene + Methyl acetate	45: 40: 15	2	4-5	6	54·0	123·2	
2.	Spirit + Trichloroethylene + Formic acid	40: 40: 20	2	4	4-5	53·2	119·7	
3.	Isopropyl alcohol + Formic acid	80: 20	3	6	6-7	2·5	12·4	
4.	Isopropyl alcohol + Petroleum ether + Formic acid	60: 20: 20	3	6-7	7	16·4	80·1	
5.	Spirit + Pyridine	50: 50	4	7	8	6·3	39·1	Swelling with 20% and 30% lac
6.	Spirit + Butyl acetate	75: 25	4-5	7	8	2·6	13·1	
7.	Isopropyl alcohol + Toluene + Phosphoric acid	75: 20: 5	5	10-11	11-12	16·0	87·3	
8.	Spirit + Trichloroethylene	50: 50	5	6-7	7	51·1	192·2	

The conventional methods which are presently followed have some limitations because in every method some loss of solvent takes place during actual determination of viscosity which indicates a faster chemical reaction than the actual one.

In order to assess the shelf life of convertible coatings a modified Ostwald viscometer, one end of which is sealed and the other stoppered, was devised in which no loss of solvent takes place during the determination of viscosity and a correct picture about the actual shelf life of such coating is obtained (Fig. 3).



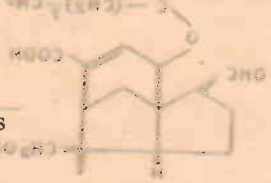
A NEW VISCOMETER FOR DETERMINING THE SHELF LIFE OF CONVERTIBLE COATINGS

Fig. 3

(b) RESEARCHES CONTEMPLATED

Since some of the items under investigation could not be completed during the year, these will be continued in 1971. Besides, the following studies are also proposed to be taken up for investigation during 1971 in view of projected completion of certain other items much in progress.

1. Modification of shellac wax
2. Dewaxing of lac in aqueous medium
3. Water thinned paints for internal decoration
4. Lac amino resin varnishes for decorative laminates
5. Modification of shellac with epichlorhydrin
6. Lac as a source of fine chemicals.



SPONSORED RESEARCH SCHEME

1. Constitution of lac

(a) *At Delhi University*

In the previous report the oxidative degradation experiments on the lac resin was reported. These experiments gave useful information regarding the mode of linking of aleuritic acid with other acids in the resin formation. It has

further been shown by a reduction followed by hydrolysis experiment on lac resin, that epishellolic acid is also a parent compound involved in resin formation. (±) *Threo*-aleuritic acid isolated from lac resin by alkali treatment was resolved into their optically active forms through their brucine salts. Their properties have also been characterised.

(b) *At National Chemical Laboratory, Poona*

The isolation and structure determination of two more smaller basic units of a lac resin is reported. Establishment of structures for the four basic units (S_4, S_5, S_6 and S_{10}) is an important step towards the confirmation of the structure of pure lac resin.

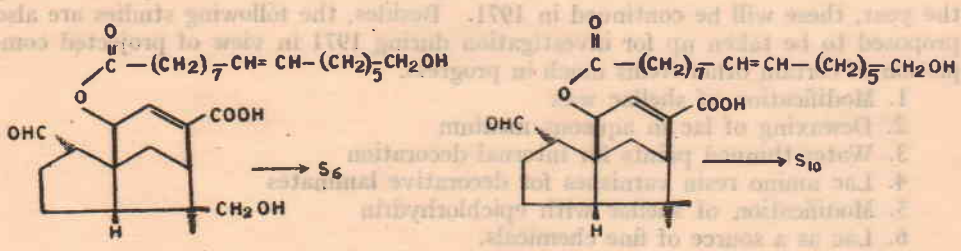
The results of the experiments on the synthesis of jalaryl aleuritate and laccl-jalaryl aleuritate are promising.

Isolation and structure determination of smaller basic units

Four basic units (S_4, S_5, S_6 & S_{10}) were isolated from soft resin by fractional precipitation method and the work on the structure of S_4 and S_5 was reported last year.

During the year under report, the remaining two units (S_6 & S_{10}) were isolated in pure form, using systematic chromatographic procedures. The separations achieved during the fractional precipitations and column chromatography, at the various stages, were checked by TLC. The pure units had the following R_f values. S_4-0·15; S_5-0·4; S_6-0·65; S_{10}-0·9; (Solvent system — Benzene, ethyl acetate; acetic acid — 20: 80: 3).

Using a procedure involving, silver oxide oxidation, hydrolysis, methylation of the total acids and the estimation of the component esters, structures were determined for S_6 and S_{10}. The I.R. and N.M.R. data collected for these two units is fully consistent with the structures proposed for S_6 and S_{10}.



2. Shellac based leather finishes at Central Leather Research Institute, Madras

In order to substitute imported toe counters, a thermoplastic composition based on lac was developed to sandwich textile fabric and later on shaped as toe counters. A concentrated lac resin was prepared almost in the form of a paste using sodium sulphite, triethanolamine and glycerol modified lac. It was applied uniformly on both sides of cloth and then pasted with another cloth. The properties of these fabrics such as thickness, hardness, heat setting and adhesion were

tested. Samples were sent to TAFCO, Kanpur (manufacturer of FLEX' shoes) and the Export Pomotion Council for Leather and reported to be satisfotacy.

Nonionic shellac wax emulsions were made by choosing proper nonionic emulsifiers like Niogen LT 180, Niogen RBL-W, Hyoxyd AAO and adding some antifoaming agent like octyl alcohol. Incorporation of an emulsion of dimethyl siloxane in Niogen LT 180 to the above nonionic shellac wax emulsion was found to enhance the properties of leather further resulting in a smooth leather with a slippery feel. The preparation of this product was standardised and scaled up to Pilot Plant.

A wax cream based on shellac wax, shellac and vegetable turpentine was formulated for shoe and leather dressings. Addition of thickeners such as perminol PWP and higher ratios of vegetable and mineral turpentines increased the tackiness. When more than 4 per cent mineral turpentine was used the gloss was reduced.

Preliminary experiments were carried out to find out the suitability of lacrylic binders in the preparation of emulsion paints used for top dressing and the product was compared with the commercial varieties. The lacrylic binders had better scratch resistance, flexibility, impact resistance, scrub resistance and water proofness but lacked covering and levelling properties.

The two major defects found in finishing of nonaqueous shellac varnish are tackiness and poor flexibility. Tackiness was found to be due to the retention of solvent by shellac while the poor flexibility to the noncompatability of this nonaqeous varnish with acrylic bottom finish. Attempts were made to bring down the tack and improve the flexibility by changing the variables such as solvent system, various modified lacs and incorporation of nitrocellulose, internal and external plasticisers, dye, pigment and wax, but so far no suitable composition could be obtainned. The use of reconstituted lac, partial butyl ester of lac and melamine formaldehyde resin will be tried.

Shellac, which softens on heating and hardens on cooling, when incorporated into chrome tanned splits and heated subsequently in dry stages, is expected to give a leather with required hardness and stiffness. It was found that impregnating with a 20 per cent shellac solution was necessary to obtain the desirable properties. Further impregnation of the above with urea-formaldehyde resin, gelatine and wax improved the hardness and stiffness making it suitable for convertion to toe covers.

Preliminary experiments were carried out to use shellac as pretanning material which will cut down the pickling operation in chrome tanning and later to reduce the moulding time when converted into cycle saddles.

Instead of retanning chrome leather with shellac, attempts were made to use shellac for pretanning raw hides. For the purpose bisulphited super blonde shellac was used in the proportion of 5% on the weight of hide. Further work is in progress.

Shellac was also used as a binding material in the manufacture of leather boards from chrome leather wastes. The leather boards so obtained were hard with good adhesion and breathing strength.

3. PAPERS PUBLISHED DURING 1970

A. ENTOMOLOGY DIVISION

Sl. No.	Authors	Title of paper	Name of Journal/ date of publication
1	Chauhan, N. S. and Mishra, Y. D.	Multiple coitus in the lac insect *Kerria lacca* (Kerr)	*Indian J. Ent.*, **32** (1), 102-3
2	Chauhan, N. S.	Occurrence of an abnormal male in the lac insect *Kerria lacca* (Kerr)	*Indian J. Ent.*, **32** (1), 103
3	Chauhan, N. S.	Genetic evidence of an unorthodox chromosomal system in the lac insect *Kerria lacca* (Kerr)	*Genet. Res.*, **16** (3), 341-44.
4	Dasgupta, J. M. and Mehra, B. P.	New record of host plants of lac insect, *Kerria lacca* (Kerr)	*Indian Forester*, **96** (5), 408-9
5	Gokulpure, R. S., Mauyra, R. C. and Mehra, B. P.	Notes on the destructive insects of *ghont* in Damoh, Madhya Pradesh	*Indian Forester*, **96** (4), 308-11
6	Gokulpure, R. S. and Mehra, B. P.	*Vitis* spp. as lac hosts from Madhya Pradesh	*Indian Forester*, **96** (6), 436
7	Kumar, P. and Purkayastha, B. K.	A note on hastening of seed germination in *Moghania macrophylla* (Willd) O. Ktze. and *Moghania chapper* Kuntze	*Sci. & Cult.*, **36** (6), 347-48
8	Malhotra, C. P. and Katiyar, R. N.	*Corcyra cephalonica* Stainl., a new predator of lac insect *Kerria lacca* (Kerr) in the laboratory culture	*Indian J. Ent.*, **32** (1), 104
9	Mehra, B. P. and Sah, B. N.	Bionomics of *Thiacidas postica* Walker (Lepidoptera: Noctuidae), a pest of *Zizi phus mauritiana* Lam.	*Indian J. Ent.*, **32** (2), 145-51
10	Naqvi, A. H., Mehra, B. P., Krishnaswami, S. and Sah, B. N.	Pruning and lac cultivation studies on *ghont*(*Ziziphus xylopyra* Willd.) (Rhamnaceae) at Namkum	*Indian Forester*, **96** (1), 37-43
11	Purkayastha, B. K. and Kumar, P.	Vegetative propagation of *Albizzia lucida* Benth. a lac host plant with growth regulators	*Sci. & Cult.*, **36** (10), 557-60
12	Sen, P. and Mehra, B. P.	Driage in *palas* broodlac	*Indian Forester* (**96** (3), 276-8

B. CHEMISTRY DIVISION

Sl. No.	Authors	Title of paper	Name of Journal/ date of publication
1	Dasgupta, A. K. and Shravan Kumar	Water thinned shellac finish for wooden furniture	*Paintindia*, **20** (9), 23
2	Ghosh, A. K. and Sengupta, S. C.	Estimation of insoluble lac resin in old lac samples	*Res. & Ind.*, **15** (3), 188-90
3	Gupta, P. C. and Sankaranarayanan, Y.	Studies in shellac etch primer Part III replacement of zinc chromate by barium potassium chromate	*Res. & Ind.*, **15** (1), 13
4	Islam, M. and Bhowmik, T.	Modification of shellac with synthetic resins for moulding purpose: Part I-U/F & BU/F resins	*Popular Plastic*, **15** (6)
5	Khanna, B. B.	Solubility parameter of shellac	*Indian J. Technol.*, **8** (7), 274
6	Khanna, B. B.	Modified lacs as compounding ingredients of styrene butadiene rubber: Part IV — Ethylene glycol modified lac in filled stock	*Res. & Ind.*, **15** (1), 11
7	Majee, R. N. and Shravan Kumar	Quick drying water proof shellac paints	*Paintindia*, **20** (9), 19
8	Majee, R. N. and Shravan Kumar	A sprayable heat water and liquor proof shellac varnish for wooden furniture	*Res. & Ind.*, **15** (3), 192
9	Misra, G. S. and Sengupta, S. C.	Shellac-Encyclopedia of Polymer Science and Technology	*Interscience publishers*, John Willey & Sons Inc., New York, Vol 12 (1970), 419
10.	Mukherjee, M. and Sankaranarayanan, Y.	Partial butyl ether/ester of shellac	*Paintindia*, **20** (8), 32
11	Pandey, A. and Bhattacharya, P. R.	Thermometric titrations of shellac solution	*Indian J. Technol.*, **8** (8), 310-12
12	Rahman, A., Banerjee, R. and Bhattacharya, P. R.	Specific heat of seed lac at different temperatures	*Indian J. Technol.*, **8** (6), 231-32
13	Rahman, A., Banerjee, R. and Bhattacharya,	Spciefic heat of bleached lac	*Indian J. Technol.*, **8** (12), 469-70
14	Shravan Kumar	A new insecticidal shellac lacquer	*Pesticides*, May (1970), 19
15	Shravan Kumar	Recent advances in the use of semi-synthetic shellac finishes	*Paintindia*, **20** (6), 28
16	Shravan Kumar	Spiritless shellac polish for wooden furniture	*Paintindia*, **20** (12), 19
17	Srivastava, B. C. and Misra, G. S.	Oil reactive/soluble modified phenolics: Part I — Curing shellac castor oil type	*Paintindia*, **20** (2), 27

4. EXTENSION

(a) ENTOMOLOGY DIVISION

As already indicated in the previous reports (A. Rep. 1968) all activities relating to extension of lac cultivation are the responsibilities of the Directorate of Lac Development Ranchi under the Ministry of Food and Agriculture, Govt. of India; the function of this Institute being limited to providing necessary technical assistance to those interested. The principal activity in this regard during the year under report was forecasting of the date of larval emergence during the different seasons and determination of the causes of excessive mortality of lac insects and crop failures on the basis of examination of samples received from different regions. Seed of flowering plants were sent to different Universities and Institutes.

The other major activity was assistance rendered to the Forest Department of the Government of Bihar in regard to "Large scale cultivation of lac on *palas* at Kundri (a hot area)". However, another project namely "Establishment and maintenance of *Kusmi* brood lac demonstration farm at Maheshpur—sirka" had to be abandoned due to certain technical difficulties faced by the Forest Department, Bihar.

Large scale cultivation on *palas* at Kundri

These experiments have been going on in Kundri lac orchard for the past several years. The orchard has a total of about 40,000 *palas* trees.

During the year approximately a total of 12384 trees were pruned in April/May for raising the *Baisakhi* cum-*Katki* 1970-71 crop and were inoculated with 6050 kg of broodlac produced in the area itself. The existing crop (*Baisakhi* cum-Katki 1969-70) on another 6500 trees were harvested which yielded 6100 kg broodlac of which only 50 kg sold at subsidized rate to the cultivators. The low yield was due to exceptionally hot summer as a result less than 50% of free reproduced little lac. The total sticklac yield was 5111 kg fetching a revenue of Rs. 4300/approx. to the Forest Department.

Namkum Plantation

General upkeep of the plantation was maintained as far as possible.

Seedlings of various lac hosts species were raised in nursery beds for filling up vacant pits in the respective plots and for experimental use in pots.

About 200 old and worn cut *kusum* and *palas* trees were coppiced for inducing the plants to develop satisfactory shoots.

Extension of pipelines has been carried out in another area of the plantation for conducting manurial trials under irrigated conditions on *bhalia* and *arhar*.

Bhalia seeds, 6 and 20 kg, and *galwang* seeds, 2 kg, were supplied to the Director, Directorate of Lac Development, Ranchi, Forest Department, Orissa and Lac Development Officer Bihar respectively for raising plantation of these bushy hosts.

(b) CHEMISTRY DIVISION

Unlike extension of cultivation, extension activities regarding increased consumption and processing aspects of lac are the complete responsibility of this Institute and are being looked into by the Utilisation Section. The main functions of this Section are technical service, developmental activities, and demonstration of and publicity and propaganda for the Institute's research findings.

Though the Senior Officer in charge of the Section retired in the middle of the year under report and the Junior Officer was not in position, the tempo of service was maintained by Officers of the Chemistry Division. As reported last year, increasing interest was noted this year also in the use of water based shellac compositions as well as compositions without use of spirit. Orders for large quantities of bleached lac and shellac were received and part of the supply was assured from the Production Unit.

Technical Service

Technical information and literature were, as usual, supplied to interested parties on request. Practical assistance by deputing our staff to the factories of the interested parties to solve technical problems as well as training in the manufacture of bleached lac at the Institute were also provided.

Technical know-how regarding methods of manufacture of shellac have been supplied to a few firms.

The gradual rise in consumption of shellac in rubber industries has been noted from the purchase of the material from some manufacturing concern. M/s. Assam Hard Board Co., Gauhati, desired to explore the possibilities of replacing synthetic resin by shellac. After carrying out laboratory experiments the possibility of partial substitution with shellac has been indicated to the firm. The Indian Jute Industries Research Association, Calcutta, desired to replace plywood for making tea chests by jute boards. Two ply and three plyboards were prepared by impregnating hessian with aqueous lac solution and sent to the party for evaluation. Three ply boards have been found satisfactory. Boards of bigger sizes have been sent for practical trials.

Due to shortage of denatured spirit in the country, many parties approached the Institute for an indegenous alternate solvent for the manufacture of French polish. After laboratory trials with various solvents, isopropyl alcohol (90%) manufactured by NOCIL has been found suitable from all respects and suggested to the parties who have already started using the solvent.

Suitable solvent mixtures have been formulated for the quick removal of shellac from and with the least swelling effect on the rubber printing rollers.

Two reputed shellac manufacturing concerns got interested in the method of manufacturing shellac directly from sticklac and they were shown the details

of the procedure. One of them was very much impressed and took down the procedural details to calculate the economics of the process. The report is awaited. One party desired to export 5 to 11 tonnes of bleached lac and was supplied the detailed technical know-how for the same.

Development Work

Results of completed research items have been propagated to the promising enterpreneurs. Some industrial concerns have been convinced to substitute imported material by shellac.

Due to paucity of staff the Institute could not actively participate in any exhibition but exhibits and charts, as usual, were sent on request for display.

Pilot Production Unit

The Unit continued the production and sale of two grades of bleached lacs (BRF and BR), autoclave shellac (ASK grade) and two grades of water soluble lacs (DXO and DXG) together with other miscellaneous lac products such as hydrolysed lacs, lac varnishes, Melfolac etc.

A drop in sale figures of bleached lac and water soluble lac was noticed during the year. The sale figures for ASK grade and other miscellaneous products, however, had shown upward trends.

The sale figures of the different grades during 1970 are given below:

Material	Quantities sold	Sale value
	Kg.	Rs.
1. BRF grade bleached lac	213·55	1,668·32
2. BR grade bleached lac	287·50	2,057·00
3. DXO grade water soluble lac	277·50	2,041·89
4. DXG grade water soluble lac	138·50	603·00
5. ASK grade autoclave shellac	2,942·00	11,802·75
6. BHL grade hydrolysed lac	53·60	750·04
7. BOL grade hydrolysed lac	24·00	288·00
8. *Kiri*	20·00	6·00
9. Miscellaneous (lac varnishes, Melfolac etc.)	—	469·00
	Total:	19,686·36

Thus during the year, the Unit has sold a total of 3859·05 kg of special shellac for Rs. 18,172·96 and other products valued at Rs. 1,513·40 amounting to a total sale value of Rs. 19,686·36, and increase of nearly Rs. 1,000 over last year.

5. CONFERENCES AND SYMPOSIA

No conference or symposia was held during the year under report.

6. SUMMARY

(A) ENTOMOLOGY DIVISION

(e) RESEARCHES COMPLETED

1. The study of relative merits of *ber* and *palas* broodlacs and their comparative performance as lac hosts had shown that *palas* broodlac is preferable for *Baisakhi* inoculation and *ber* for *Katki*. As hosts *palas* is particularly suited for *Baisakhi* and *ber* for *Katki* seasons.

2. The performance of broodlacs harvested earlier than the time of normal larval emergence in nature had shown that *ber* broodlac can be safely harvested even a week earlier than the usual time of larval emergence without losing much of its brood value.

(b) RESEARCHES IN HAND

1. Brood rate trials for *palas* in a hot area had shown that the *ari* yield was maximum with a brood rate of 1·8 kg per tree.

2. The possibility of utilising *bhalia* for raising a *Jethwi* crop could not be examined due to non-availability of sufficient broodlac for the experiment.

3. The field experiment designed to compare the newly developed cultivation schedule for *kusum* with the standard four coupe system also could not be continued due to non-availability of sufficient broodlac for the experiment.

4. In a search for alternate lac hosts to fortify production of *Kusmi* and, *Rangeeni* crops, *galwang* had proved a satisfactory *Kusmi* host and *Jaharphali pakur* and *putri* as *Rangeeni* hosts.

5. Comparative performance of the known important lac hosts for lac production showed that *kusum* and *bhalia* are best suited for *Kusmi* lac and *palas* for *Rangeeni*.

6. Attempts to train the tree host species into suitable bush for intensification of lac production on bushy hosts were successful in the cases of *galwang*, *ber* and *palas*.

7. In order to induce drought resistance in bushy lac hosts for raising the summer lac crops, temperature treatment of seeds of *bhalia* prior to sowing showed that the transpiration is lowest with exposure to higher temperatures (70°C)

In the case of *arhar*, the shoot growth was best in plants raised from seed exposed to the highest temperature (70°C) prior to sowing.

Varietal trials of *arhar* showed that the variety NP 39 is best so far as shoot growth is concerned.

8. Besides *galwang*, *bhalia* could also be raised successfully from shoot cuttings with the use of plant growth hormones.

9. Chromosome number of the important lac hosts was determined and chromosome morphology of some of the *arhar* varieties studied.

Irradiation of *bhalia* and *arhar* seeds was found to adversely affect the plant growth with the increase in radiation dose.

Colchicine treatment at the seedling stage of *bhalia* showed that the shoot growth is adversely affected with the higher concentrations of colchicine.

10. Studies could not be persued further as the worker left.

11. Microflora of the *Rangeeni* and *Kusmi* strains of lac insects reared on different hosts was compared and found to differ in the two strains and also when the same strain was reared on different food plants. Biochemical tests were made with these microorganisms isolated from the two strains of lac insect.

12. The possibility of combining the *Kusmi* resin characteristics with the *Rangeeni* life cycles was examined in crosses of the *Rangeeni* and *Kusmi* strains of lac insects to enable large scale production of the superior *Kusmi* lac on *palas*.

13. Studies with the colour genes have shown a unique chromosomal situation in the male lac insect, which though somatically a diploid breed, as a haploid transmitting only the maternal genome through the sperm.

Further evidence of somatic diploidy of the male lac insect was obtained using a physiological strain difference in these insects.

14. Attempts were made to induce economically desirable mutations in lac insects using X-ray.

15. Study of the strain crosses in lac insects had shown that the *Kusmi* strain is genetically endowed to survive normally on *kusum*, but not the *Rangeeni* and that the ability of *Kusmi* to survive is dominant to the inability of *Rangeeni* to do so.

16. Sex ratio was found to differ in the different batches of larval emergence within individual progenies of lac insects; the proportion of male was highest in the earliest batch of emergence and declined sharply and progressively in the subsequent batches.

17. Lac insects were found to have an unusual mating system in that the lac females are usually mated to a number of males so that the progeny from a mother lac insect comprise both full and half sibs.

18. The larvae of the lac predator *A. amabilis* were found attacked by two bactorial diseases. These bacteria were isolated and their pure culture maintained for their identification.

19. With a view to develop a suitable synthetic diet for mass breeding the important beneficial parasites attacking the lac insect predators, the *p*H of the digestive tract of the predatory larvae was determined and found to be alkaline. The digestive enzymes detected were amylase, maltase, invertase, lactase, lipase, pepsin and trypsin.

20. Seasonal incidence of the beneficial parasites was studied in lac crops raised on tree and bush host species and some of these parasites were also reared in the laboratory on an alternate host, *Corcyra cephalonica*.

22. Studies were continued on the food habits, species composition seasonal incidence, ilfe history and parasites and diseases of the limacedid pests of lac hosts.

23. Photoperiod was found to have no direct effect on the development of lac insects. Indirect effects will now be studied.

Routine investigations on the locally available lac hosts were continued at the Regional Field Research Station at Dharamjaigarh, M.P.

(B) CHEMISTRY DIVISION

1. (a) Shellac was prepared directly from *Rangeeni* and *Kusmi* sticklac extracting with alcohol or acetone in higher yields. Improvements in life and flow were observed while colour was not to expectation. Processes to recover wax and water soluble dye have also been developed.

(b) Dewaxing of lac by addition of barytes to an aqueous solution of lac was found comparatively more economical.

(c) Bleaching of lac by hydrogen peroxide in sodium bicarbonate solution effectively reduced the colour index by about 4 units while a combination of sodium hypochlorite and hydrogen peroxide reduced the colour index to 0·31 and the bleached lac had good flow and life.

2. (a) It was found that hydroperoxidation of lac is more effective in solvent medium when lac is grafted with vinyl monomers.

(b) Lac/urea resin films cure in the cold and also in presence of *p*-toluene sulfonic acid as catalyst. The role of functional groups in the reaction has been studied.

(c) Some physical and chemical constants of hydrolysed product from sulphuric acid modified lac were compared with the hydrolysed lac of parent lac. Examination of their methyl esters by thin layer chromatography showed no appreciable difference between them.

(d) By heating *total* hydrolysed lac at 150°C a product is obtained which has been termed as "Rebulac". The various film properties in aqueous medium of *Rebulac* and the one obtained by heating hydrolysed lac with linseed oil fatty acids have been studied. Method for bleaching *Rebulac* has also been standardised.

3. (a) Lac resin was resolved into eight components by the application of thin layer chromatography.

(b) The equations evolved from the relationship between molecular weights and intrinsic viscosities of various fractions of hard resin shellac and polymers of acetonated aleuritic acid are respectively as follows:

$$[\eta] = 19{\cdot}95 \times 10^{-4} M^{\cdot 50}_{30^\circ}$$

$$[\eta] = 7{\cdot}08 \times 10^{-4} M^{\cdot 65}_{30^\circ}$$

and

$$[\eta] = 7{\cdot}943 \times 10^{-4} M^{\cdot 65}_{30^\circ}$$

(c) Further investigation on the constitution of soft resin resulted in the isolation and characterisation of nineteen constituent acids accounting nearly 90% of the resin.

4. (a) The dielectric properties of lac/urea and lac/melamine resin varnishes were compared and other properties bearing ASTM specification studied.

(b) Dielectric loss of lac-natural rubber combination with CBS as accelerator was studied.

5. The degree of depolymerisation and rate of dissolution of polymerised shellac in acidic alcohol was studied.

6. The work on the identification of shellac in presence of other resins has been kept in abeyance since no reproducible results were obtained.

7. (a) A water thinned polish for wood, based on water soluble lac, urea and maleic resins, was developed and its film properties studied.

(b) A solid composition soluble in water for wood polish was also prepared by exposing lac and maleic resins to ammonia vapour.

8. (a) The effect of three accelerators, tetramethyl thiuram disulphide (TMTD), CBS and MBT on the combination of shellac with natural rubber, was studied.

(b) The estimation of free sulphur and determination of crosslink density in vulcanised samples of shellac-natural rubber combination was carried out against time factor.

9. Due to shortage of staff the work on lac and lac derivatives as modifiers for phenolic resins for plastics could not be pursued.

10. (a) Two emulsion paints, one based on lac-linseed oil combination and the other by emulsifying lac/melamine resin varnish in triethanolamine were formulated having satisfactory film properties.

(b) The variation of hydrogen ion concentration and specific conductivities of a few pigmented and unpigmented primers on storage were examined. The changes in binder properties in the primers were also studied in relation to their throwing powers.

(c) Shellac was modified with epoxy resins (epikote 1000 and 834) in solvent medium using catalyst and their film properties studied.

(d) A method for maleinisation of oil with maleic acid was standardised. A primer was developed with the oil and ammoniated shellac, etc. and their film properties studied.

(e) The solvent release from dewaxed shellac film was studied by exposing the films at room temperature and also at 40°C for different periods of time.

(f) Film performances of enamel paints based on lac-oil combination in presence of melamine resin, a drier and a curing agent gave desirable results.

(g) A sprayable varnish prepared by dissolving lac in mixed solvents gave smooth glossy finish. Commercial *iso*propyl alcohol containing 10% water proved to be an alternate solvent for lac to spirit for the preparation of French polish.

11. The possibility of replacing plywood teachests with jutelac boards was investigated and practical trials are in progress. Attempts also were made to replace imported phenol-pormaldehyde resin with shellac for manufacture of hard boards from wood pulp.

12. Lac-coated urea fertilizer was developed which was tested under several conditions and agronomical studies carried on or a few crops. A new coating technique with powdered shellac was developed and dissolution rate studied.

13. The adhesive property of *Kusmi*, *Rangeeni* and dewaxed shellac with metal panels were studied.

14. (a) A suitable solvent to dissolve shellac from rubberised printing rollers was found which showed least action on rubber.

(b) The film properties of some shellac films prepared from mixed solvents were studied.

(c) A modified viscometer for determining the shelf life of catalysed varnishes was devised.

7. METEOROLOGICAL REPORT FOR THE YEAR 1970

The average meteorological data for each month during the year 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 hrs/day	Total rainfall mm	Highest maximum temp. (°C)	Lowest minimum temp. (°C)
1	2	3	4	5	6	7	8	9	10	11
January	708·8	24·2	9·6	16·1	13·5	74	7·14	27·5	25·9	5·5
February	707·8	26·7	12·3	18·7	15·3	69	7·99	43·1	32·6	8·1
March	705·1	30·2	16·7	23·7	19·9	68	7·68	52·2	38·1	12·9
April	703·2	37·3	21·7	31·2	23·8	54	7·69	21·8	41·3	17·5
May	699·5	37·8	23·9	31·6	25·2	58	7·83	52·3	43·6	18·2
June	697·8	33·1	23·6	27·9	25·2	80	5·54	212·0	35·6	21·1
July	696·9	31·1	23·0	26·3	24·5	86	3·24	668·2	38·6	21·4
August	698·2	29·8	23·0	26·3	24·7	88	4·04	268·8	32·5	21·5
September	699·3	29·1	22·1	25·6	24·0	88	4·68	692·0	32·2	20·4
October	703·6	29·9	18·8	26·1	22·8	74	7·25	13·4	32·0	13·6
November	707·2	25·5	11·2	21·9	17·4	63	8·48	Nil	30·4	5·7
December	708·3	24·5	6·9	17·8	13·5	60	8·47	Nil	25·7	4·6

The highest maximum temperature recorded was 43·6°C on 15th May and the lowest minimum 4·6°C on 8th December. The total rainfall during the year amounted to 2051·1 mm of which the monsoon (June to Sept.) rainfall was 1841·0 mm. The rainfall during the year was much higher than the normal (about 1500 mm) for this station and it was the highest recorded during the last 10 years. The maximum rainfall recorded in 24 hrs was 219·5 mm on 6th July. There was hail storm on 18th May.

8. PERSONNEL

Shri Y. Sankaranarayanan, Director, retired from the services of the Institute on the afternoon of Monday the 7th September, 1970. Shri S. C. Sengupta, Senior Scientific Officer (Organic) in the Institute has taken over charge of Director in place of Shri Y. Sankaranarayanan.

STATEMENT SHOWING APPOINTMENTS, PROMOTIONS, RESIGNATIONS, RETIREMENTS ETC. DURING JANUARY-DECEMBER 1970

Name	Post to which appointed	Date
A. Appointments		
1. Shri K. M. Prasad	Research Assistant	7-3-1970
2. Shri S. C. Sengupta	Senior Scientific officer (Organic)	18-8-1970
3. Shri S. C. Sengupta	Director	7-9-1970 (A/N)
B. Promotions		
1. Shri Sant Kumar	Junior Field Asstt.	28-2-1970 (A/N)
C. Resignations		
1. Miss Kanta Rani Lal	Research Assistant	5-2-1970
2. Shri D. K. Guha Sircar	Research Assistant	2-3-1970
3. Shri U. P. Griyaghey	Research Assistant	8-7-1970 (A/N)
4. Shri B. C. Lakra	Museum Assistant	10-7-1970 (A/N)
5. Shri G. K. Jha	Laboratory Asstt.	3-8-1970
D. Retirement		
1. Shri Y. Sankaranarayanan	Director	7-9-1970 (A/N)
2. Dr. T. Bhowmik	Senior Scientific Officer (Utilisation)	8-7-1970
3. Shri P. C. Ghosh	Senior Research Asstt.	1-12-1970

RESEARCH STAFF: DIVISIONWISE

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-12-1970
1	Director	1	Sri S. C. Sengupta
Entomology Division			
2	Entomologist	1	Dr. A. Bhattacharya
3	Scientific Officer (Cultivation & Training)	1	Sri B. P. Mehra
4	Scientific Officer (Field Station)	1	Sri C. P. Malhotra

Sl. No.	Name of the post	Sanctioned strength	Staff in positiou as on 31-12-1970
5	Scientific Officer (Insect Genetics)	1	Sri N. S. Chauhan
6	Scientific Officer (Arboriculture)	1	Vacant
7	Scientific Officer (Physiology)	1	Vacant
8	Scientific Officer (Biology)	1	Vacant
9	Senior Research Assistant	7	1. Sri B. K. Purkayastha 2. Sri R. S. Gokulpure 3. Sri A. H. Naqvi 4. Sri N. Majumdar 5 to 7 Vacant
10	Instructor (Lac Cultivation)	1	Sri R. C. Misra
11	Research Assistant	14	1. Sri Parimal Sen 2. Sri A. K. Sen 3. Sri S. G. Choudhary 4. Sri B. N. Sah 5. Sri J. M. Das Gupta 6. Sri R. C. Maurya 7. Sri Pranaya Kumar 8. Sri Y. D. Misra 9. Sri M. L. Bhagat 10. Sri S. K. Jaipuriar 11. Sri Jawahirlal 12. Sri M. K. Chowdhury 13 to 14 Vacant
	Junior Research Assistant working against the vacancy of Research Assistant		
12	Insect Collection Tender	1	Sri Md. Ali Ansari
13	Laboratory Assistant	7	1. Mrs. Namita Nandy 2. Sri Ajmer Husasin 3. Sri D. D. Prasad 4. Sri R. D. Pathak 5. Sri R. C. Singh 6 to 7 Vacant
Chemistry Division			
1	Senior Scientific Officer (Organic)	1	Sri S. C. Sengupta
2	Senior Scientific Officer (Utilisation)	1	Vacant
3	Scientific Officer (Physical)	1	Dr. P. R. Bhattacharya
4	Scientific Officer (Applied)	1	Vacant
5	Scientific Officer (Decorative Coating)	1	Sri Shravan Kumar
6	Scientific Officer (Factory)	1	Dr. B. B. Khanna
7	Scientific Officer (Utilisation)	1	Vacant
8	Junior Scientific Officer	1	Sri P. K. GHOSH
9	Senior Research Assistant	6	1. Sri A. K. Ghose 2. Sri A. Kumar 3. Sri P. C. Gupta 4. Sri T. R. Laxminarayanan 5. to 6 Vacant
10	Senior Analyst	1	Sri L. C. Misra
11	Research Assistant	17	1. Sri A. Rahman 2. Sri R. N. Banerjee 3. Sri S. K. M. Tripathi 4. Sri August Pandey 5. Sri M. Mukherjee 6. Sri M. Islam 7. Dr. S. C. Agarwal 8. Sri A. K. Dasgupta 9. Sri B. C. Srivastava 10. Sri Niranjan Prasad 11. Sri Radha Singh

Sl. No.	Name of the post	Sanctioned strength	Staff in position as on 31-12-1970
			12. Sri R. N. Majee
			13. Sri R. S. Prasad
			14. Sri K. M. Prasad
			15 to 17 Vacant
12	Analyst	2	1. Sri B. P. Banerjee
			2. Sri Ramesh Prasad
13	Glass Blower	1	Sri S. K. Dey
14	Laboratory Assistant	10	1. Sri Dominick Runda
			2. Sri Noas Minz
			3. Sri G. M. Borkar
			4. Sri B. B. Chakravarty
			5. Sri Nagendra Mahto
			6. Sri Umeshwar Sahay
			7. Sri B. P. Keshri
			8. Sri M. K. Singh
			9 to 10 Vacant
15	Museum Assistant	1	Vacant

Fourth Five Year Plan Posts

1. *Entomology Division*

1	Head of the Division of Entomology	1	Vacant
2	Agronomist	1	Vacant
3	Insect Geneticist	1	Vacant
4	Senior Research Assistant	1	Vacant

2. *Chemistry Division*

1	Head of the Division of Chemistry	1	Vacant
2	Scientist (Technology)	1	Vacant
3	Scientific Officer (Polymer)	1	Vacant

Staff Club

The Staff Club continued its activities as usual towards which the Institute made a recurring contribution of Rs. 433/- for 1970-71.

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