INDIAN LAC RESEARCH INSTITUTE
NAMKUM, RANCHI, BIHAR, INDIA

Annual Report
1973

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI
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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 wherein 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 out-turn. 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 Indian Lac Association for Research 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. Agronomy Division is temporarily accommodated in one small room spared by Entomology Division. The Institute Library adjoins the Entomology building. The Administrative Section and Museum are housed in another block. The water-works, 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 Divisions.

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 Numkum including the plantation covers an area of about 49 hectares. For out-station experiments, areas/trees have been taken on long term basis.

Objectives

The objectives of the Institute are:

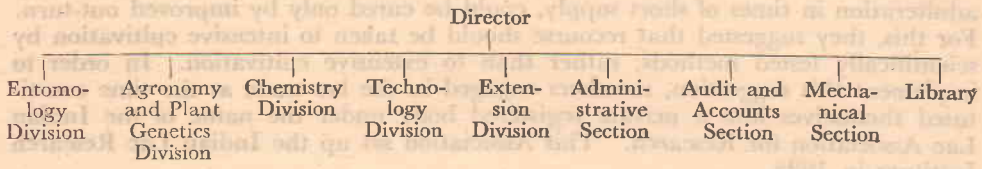
1) To carry out research towards affecting improvements in the cultivation, processing, standardization, and modification of lac to intensify its production and extend utilization,

2) To extend the results of research through publicity, maintaining liaison with and providing technical service to lac growers and indigenous industries towards increased utilization of lac and improving the quality of their products, and
3) To impart training in improved methods of lac cultivation and industrial uses of lac.

Organizational structure

The Institute is organized into five main Divisions, namely, Agronomy and Plant Genetics, Chemistry, Entomology, Extension, Technology and Utilization. The Divisions of Chemistry and Entomology are headed by their respective Head of Division, while the other three are under the charge of their respective seniormost Scientist.

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



Achievements

Entomology

Among the notable results, particular mention may be made of the discovery of white lac insect which is considered significant in view of the industrial demand for a dye-free lac resin. This insect is now being studied to examine the possibility of evolving a strain producing the much sought after dye-free resin.

Studies on the free amino acid content of the *rangeeni* and *kusmi* strains of lac insects have shown interesting strain, age and season specific differences which could now be used for the idenitification of the strains on the basis of such biochemical differences.

Agronomy and Plant Genetics

In order to get desired plant characters and multiply them within a short period from lac production stand point, the plants of *galwang* (*Albizzia lucida*), *bhalia* (*Moghania macrophylla*), *pansura* (*Grewia serrulata*) and rain tree (*Samanea saman*) were successfully raised from stem cuttings using growth regulator mixtures in different months. March planting with IBA+IPA at 100 ppm for *galwang*, and June planting with IPA+NAA at 50 ppm for *bhalia*, with IAA+NAA at 100 ppm for rain tree and with IBA+IAA at 50 ppm for *pansura* were found best in establishing large number of rooted plants.

Chemistry

A quick method was developed to identify shellac in presence of other resins through spot test, using fuchsin sulphurous acid in the mother liquor after hydrolysis.

The products obtained by modifying total hydrolysed (refuse) lac with phthalic anhydride gave good performance when used in water thinnable paint formulations. The paints could be stored for more than a year in air tight containers and no deterioration in the properties was noticed.

Technology

A technique has been developed to improve the quality of wax recovered from lac effluents. The wax, so obtained, possesses better hardness and solvent retentivity.

Library

The number of books and bound volumes of journals accessioned during the year was 612. This brought the total number of books and volumes of journals in the library as on 31st December 1973 to 14,833. One hundred and forty-eight periodicals were subscribed in addition to a few received in exchange or as gift. Some miscellaneous publications and reports were also received.

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

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. These included, among others, the following:

1. Prof. S. C. Mandal, Vice Chancellor, Rajendra Agricultural University, Bihar.
2. Dr. T. R. Mehta, Dy. Director General, ICAR, New Delhi.
3. Sri Tushar Kanti Ghosh, Editor, Amrita Bazar Patrika.
4. Dr. H. R. Arakeri, Member, National Commission on Agriculture, Govt. of India, New Delhi.
5. Dr. S. K. Mukherjee, Member, National Commission on Agriculture, Govt. of India, New Delhi.
6. Dr. P. Bhattacharya, Member, National Commission on Agriculture, Govt. of India, New Delhi.
7. Prof. Sadhan Basu, Department of Chemistry, Calcutta University, Calcutta.
8. Mr. Tsunetomi Katsu, Chemical Dept., G.I.F.U., Shellac Manufacturing Co. Ltd, Japan.
9. Mr. Mobuzo Ogi, G.I.F.U., Shellac Manufacturing Co. Ltd., Japan.

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. 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 shellac coated urea developed at the Institute was got tested in agronomical trials for comparison with sulphur coated urea under the All India Coordinated Rice Improvement Project (ICAR), Hyderabad.

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

Research collaboration at International level

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

Training and advisory services

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

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

Conferences and symposia

A two-day Seminar on Lac Production was organized on 9-10 November 1973 at the Institute. The seminar was inaugurated by Dr. T. R. Mehta, Deputy Director General, Indian Council of Agricultural Research, New Delhi.

Finance

Initially the Institute was financed through a cess levied on all exports of lac. Since 1962-63, however, some grants were also received from the Government of India as the income from the cess was inadequate. With the take over of the Institute by the Indian Council of Agricultural Research with effect from 1st April 1966, it is being wholly financed by the Council.

The final revised budget estimates of the Institute for 1973-74 amounted to Rs. 21,03,000. The actual expenditure, however, was Rs. 17,64,835.

2. PROGRESS OF RESEARCH

A. ENTOMOLOGY DIVISION

(a) RESEARCHES COMPLETED

Nil

(b) RESEARCHES ON HAND

Lac cultivation studies

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

Bhalia (*Moghania macrophylla*) possesses several attractive features as a lac host but it is unable to sustain the summer crop. The present study is taken up to examine whether an *ari* (immature) or a partial summer crop is possible with crop inoculation on 12-month-old shoots in January-February using varying amounts of broodlac.

The experiment is laid out on a randomized block design for the following practices, each tried on 5 bushes with 10 replications:

Treatment	*Brood rate/bush*	*Harvesting*
A	400 g	The crop is harvested completely as *ari* in the following May
B	200 g	Partial harvesting as *ari* in May and complete, harvesting in January-February next
C	100 g	As in Treatment B
D	50 g	Harvesting completely in January-February next
E	400 g	Harvesting completely on crop maturity in June-July
F	100 g	As in treatment C with foliar spray of 1% urea at weekly intervals for one month after the appearance of the new flush of leaves
G	50 g	As in treatment D with foliar spray of urea as in Treatment F

The data for the harvesting made during the period under report are set out in Table 1. It will be seen from this table that the crop performance has not been satisfactory when it was harvested completely as *ari* (Treatment A) or as the *jethwi* crop (Treatment E). The complete data for the other practices are awaited.

TABLE 1 — COMPARISON OF THE CROP PERFORMANCE UNDER VARIOUS PRACTICES TRIED FOR RAISING THE SUMMER CROP ON *bhalia*

Treatment	Brood used (kg)		Stick lac yield (kg)	
	Lac stick	Stick lac	*ari*	Mature
A	20·000	4·420	2·159	—
B	10·000	2·770	0·689	—
C	5·000	1·700	0·619	—
D	2·500	0·798	—	—
E	20·000	3·370	—	2·563
F	5·000	1·010	0·554	—
G	2·500	1·037	—	—

(R. C. Maurya and A. Bhattacharya)

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

Cultivation experience had shown that *kusum* (*Schleichera oleosa*) does not respond well to pruning in January-February for successful operation of the standard four-coupe system. A new cultivation schedule involving complete harvesting-cum-pruning in July is thus being tried and the performance compared with those of the standard four-coupe system and the villagers' practice.

The experiment is laid out on a randomized block design with one tree under each practice and 13 replications. The cultivation practices tried are: (i) the new two-coupe system involving crop inoculation on 12-month-old shoots in July with partial harvesting in January-February for raising both the self and artificially inoculated *jethwi* crop on 18-month-old shoots which are harvested completely on maturity in July (Treatment A), (ii) the standard four-coupe system with artificial inoculation and complete harvesting in each crop season (Treatment B) and (iii) the villagers' practice involving initial artificial inoculation and subsequent partial harvesting in each crop season (Treatment C).

The experiment could be carried out only with 10 replications due to non-availability of sufficient broodlac. From the data furnished in Table 2, it will be seen that the crop performance with the new cultivation schedule (Treatment A) was not better than that under the standard four-coupe system (Treatment B).

TABLE 2 — CROP PERFORMANCE UNDER THE DIFFERENT CULTIVATION PRACTICES TRIED FOR *kusum*

Treatment	Brood used (kg)		Yield (kg)		Crop ratio*
	Lac stick	Stick lac	Lac stick	Stick lac	
A	40·80	17·90	377·40	166·30	1:8·45
B	40·80	19·00	393·20	167·50	1:8·81
C	40·70	20·70	134·70	47·20	1:2·52

*Crop ratio refers to the ratio of yield to broodlac used in terms of sticklac.

(R. C. Maurya and A. Bhattacharya)

3. Finding out alternate hosts for *kusmi* and *rangeeni* strains of lac insects and conducting cultivation on them

Bara-salpan (*Moghania chappar*) was tried as an alternate host to *kusum*, but it performed poorly both in the *jethwi* 1973 and *aghani* 1973-74 crop seasons.

Rain tree (*Samanea saman*) and *putri* (*Croton oblongifolius*) were tried for the *rangeeni* lac. Both performed poorly in the *baisakhi* 1972-73 and *katki* 1973 seasons. They have, however, sustained the *baisakhi* 1973-74 insects fairly satisfactorily till the end of the period under report.

(M. L. Bhagat and A. Bhattacharya)

4. Studies on the efficacy of different lac hosts on the survival of lac insects

The ten host species, namely, *kusum*, *galwang* (*Albizzia lucida*), *ber* (*Ziziphus mauritiana*), *sandan* (*Ougeinia oojeinensis*), *palas* (*Butea monosperma*), *arhar* (*Cajanus cajan*), *khair* (*Acacia catechu*), *vilaitibabul* (*Acacia farnesiana*), *rain tree* and *bhalia*, studied earlier under the potted condition, were now studied in the field. Five plants of each host species were used for raising cultures of each of the *rangeeni* and *kusmi* insects. Samples were collected at three stages in the development of these insects, namely (i) two days after settlement, (ii) at sexual maturity and (iii) at the time of crop maturity to study initial density of settlement, sex ratio and final survival of the females. Data were also maintained for fecundity and resin output of the female lac insect.

The *kusmi* strain of lac insects survived on *kusum*, *bhalia* and *galwang* in the *jethwi* 1973 and on *kusum*, *bhalia*, *sandan* and *palas* in the *aghani seasons*. The overall performance has been best on *kusum*.

The *rangeeni* strain of lac insect survived on *palas*, *ber*, *bhalia*, *galwang*, *rain tree*, *vilaitibabul* and *sandan* in both the *baisakhi* 1972-73 and *katki* 1973 seasons, and on *khair* also in the *katki* 1973 season. The data collected for the survival, fecundity and resin output of lac insects, however, failed to provide a consistent picture except that *palas* alone has figured among the top five host species for these qualities.

(M. K. Chowdhury and A. Bhattacharya)

5. Intensive lac cultivation under bushy condition

This study aims at studying the performance of the trained bushes of three host species, namely, *palas*, *ber* and *galwang* as compared to that of the *palas* trees under the three-coupe, two-coupe and the villagers' system. The experiment is laid out on a split plot design with three main plot treatments (brood rates) and three sub-plot treatments (fertilizer application).

The *baisakhi* 1972-73 crop on *palas* and *galwang* and the *katki* 1973 on *ber* could not be raised due to crop failures.

(M. L. Bhagat, A. Bhattacharya and B. K. Purkayastha — Cooperator)

Physiological studies on lac insects and associated insects

6. Qualitative estimation of amino acids in the body fluid of the lac insect at different stages in relation to different host plants

The amino acid content of the body fluid of *rangeeni* and *kusmi* strains of lac insects was determined at two stages in their development, namely, the immature

larvae and fully matured female, following two dimensional paper chromatography. For this purpose, the *rangeeni* insects were reared on *palas*, *bhalia* and *ber* in the *baisakhi* 1972-73 season and on *ber* in the *katki* 1973, and the *kusmi* insects on *bhalia*, *ber* and *kusum* in the *jethwi* 1973 season and on *ber* and *kusum* in the *aghani* 1973-74.

The insect body fluid was passed through cation exchange resin column, treated with 6N ammonia and dried on a water bath. Ethanol was added to the residue which was then centrifuged. The supernatant liquid was concentrated and spotted on a Whatman No. 1 filter paper. The solvent systems used were phenol : water (4:1 w/v) in the first dimension and *n*-butanol : acetic acid: water (30:6:14 v/v/v) in the second.

It will be seen from Table 3 that while serine, glycine, threonine, alanine, cysteine, tyrosine, valine and iso-leucine were present in both the stages of the *rangeeni* and *kusmi* insects, methionine was present only in the *rangeeni*, and glutamic acid, proline and hydroxyproline exclusively in the *kusmi* insects. Lysine was present only in the matured female of the summer generations of the two strains (*baisakhi* and *jethwi*), histidine in both the stages of the summer generation of the *rangeeni* insects (*baisakhi*) and aspartic acid in both the stages of the summer generations of the two strains and only in the matured female of the rainy generation of the two strains (*katki* and *aghani*). It will thus be seen that while a number of amino acids are common to the two strains of lac insects, a few are specific to strains, season and stage of insect development.

TABLE 3 — AMINO ACID CONTENT OF THE BODY FLUID OF LAC INSECT

Sl No.	Amino acid	*Katki*		*Baisakhi*		*Aghani*		*Jethwi*	
		Immature larvae	Fully matured female	Immature larvae	Fully matured female	Immature larvae	Fully matured female	Immature larvae	Fully matured female
1	Alanine	+	+	+	+	+	+	+	+
2	Cysteine								
3	Isoleucine								
4	Glycine								
5	Serine								
6	Threonine								
7	Tyrosine								
8	Valine								
9	Methionine	+	+	+	+	−	−	−	−
10	Glutamic acid	−	−	−	−	+	+	+	+
11	Proline								
12	Hydroxyproline								
13	Histidine	−	−	+	+	−	−	−	−
14	Aspartic acid	−	+	+	+	−	+	+	+
15	Lysine	−	−	−	+	−	−	−	+

(R. S. Gokulpure, A. H. Naqvi and T. P. S. Teotia — Cooperator)

7. Evolution of a suitable synthetic diet for artificial rearing of lac insect

The problem involves (i) finding out a suitable substrate for the settlement of the lac larvae and (ii) evolution of a suitable diet for their feeding.

During the period under report, solidified agar-agar soaked in diets made up of amino acids, vitamins, mineral salts and sucrose was used for the settlement of lac larvae and their feeding with or without a polythene film cover. Polythene tubes filled with the diets were also used for this purpose. Dithane M-45 was tried to check the fungal growth on the insects and in the diet.

The lac insects, however, survived for no longer than a week.

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

8. Nutritional requirements of the predators *Eublemma amabilis* Moore and *Holcocera pulverea* Meyr. and evolution of a suitable artificial diet

The investigation is taken up for mass rearing of the predators to ensure their regular supply for various laboratory experiments.

Newly hatched caterpillars of *Eublemma amabilis* Moore were offered soft agar-agar globules containing casein and peptone. The survival was noted for a period of 40 hr as compared to 10-12 hr when starved.

In another experiment, 25 newly hatched caterpillars of *E. amabilis* and an equal number of the field collected third instar caterpillars each of *E. amabilis* and *H. pulverea* were offered the diets shown in Table 4. These diets were offered both in the dry powder and moistened forms. Sorbic acid (0·3 per cent) was used as an antifungal agent. The insects were maintained at 25°-27°C and 75-80 per cent R.H. None of these diets was acceptable to the newly hatched caterpillars of *E. amabilis*. In the case of the field collected caterpillars, the survival was maximum for a period of 25 days on diets 3 and 4 for *E. amabilis*, but none of them pupated. For *H. pulverea*, the survival was best on diet 4 and 60 per cent caterpillars pupated. Of these, 7 adults emerged which, however, could not be paired for further studies since the sexes appeared at different times.

TABLE 4 — DIETS TRIED FOR ARTIFICIAL FEEDING OF THE PREDATORS OF LAC INSECTS

Diet	Composition	Quantity (g)
1	Casein	2·500
	Peptone	0·500
2	Casein	2·500
	Palmitic acid	0·008
	Myristic acid	0·004
	Stearic acid	0·004
	Cholesterol	0·004
3	Casein	2·500
	Palmitic acid	0·008
	Myristic acid	0·004
	Stearic acid	0·004
	Cholesterol	0·004
	Glycogen	0·004
	Galactose	0·004
4	Casein	2·500
	Peptone	0·500
	Palmitic acid	0·008
	Myristic acid	0·004
	Stearic acid	0·004
	Cholesterol	0·004
	Glycogen	0·004
	Galactose	0·004

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

9. Studies on the role of microorganisms present in lac insect

Work on the isolation of the microorganisms from the *rangeeni* and *kusmi* lac insects was continued during the period under report. For this purpose, the lac insects were cultured on *bhalia*, *palas*, *ber* and *kusum*. The microorganisms were isolated from the body fluid of the lac insects and their pure cultures maintained on agar-agar slants at 4°C for further studies.

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

10. Studies on sex attraction in major lepidopterous predators

During the period under report, observations were made on the mating behaviour of the two lepidopterous lac predators, namely, *E. amabilis* and *H. pulverea*.

The presence of sex attraction was confirmed in the female of these predators.

(A. K. Sen and T. P. S. Teotia)

Breeding and genetical studies on lac insects

11. Adaptation of the *kusmi* lac insect to a common food plant to boost production of the superior lac

Rearing experience had shown that *palas* which produces the bulk of lac of commerce is not deficient in nutrients essential for the growth and reproduction of the superior *kusmi* strain of lac insects, but it is not suited for their propagation probably because it is not in the right physiological state during the *kusmi* cycles. Experiments were thus taken up in which the possibility of obtaining the *kusmi* insect at the *rangeeni* inoculation times is being examined through cross-breeding of these strains of lac insects.

It was reported earlier (A.R., 1972) that a few *kusmi* type insects had provided the lac larvae at about the *rangeeni* inoculation time in the last rainy season in one of F_4 lines derived from the strain crosses. These insects, however, were lost during the summer months.

In 1972, a *kusmi* broodlac was obtained from Tamil Nadu which had provided the lac larvae at the desired *rangeeni* inoculation time towards the end of the last rainy season. It was thus of interest to study the behaviour of these insects on *palas* during the *baisakhi* 1972-73 cycle. These insects have taken about 13 months on an average for completion of the two cycles.

(Jawahir Lal and N. S. Chauhan)

12. Study of crosses

(i) *Discovery of a lac insect producing white lac*

A few insects of both sexes produced white lac in a F_4 progeny derived from crosses of two distinct races of lac insects, one obtained from Tamil Nadu and the other from Punjab. The discovery is considered significant in view of the industrial demand for a dye-free lac for which the lac is presently bleached which not only involves considerable expenditure but also adversely affects some of the desirable properties of the lac resin.

The white lac insects, however, were lost just when they were due to produce a progeny due to ant damage. Subsequent screening of the wild stocks of lac in-

sects showed the occurrence of this new colour variant in extremely low frequencies in two of the eight wild stocks maintained at this Institute. This would suggest that the white lac variant could be a recessive mutant with a selective disadvantage in the natural environment.

(N. S. Chauhan)

(ii) The life period difference of the *rangeeni* and *kusmi* strains of lac insects was studied in crosses of the two strains. The rainy generation life period of the wild stocks of the two strains and their crosses is shown in Table 5.

TABLE 5 — COMPARISON OF AVERAGE RAINY GENERATION LIFE PERIOD IN FOUR WILD STOCKS AND THEIR CROSSES

Genotype		Progeny	
		Number tested	Mean life period (days)
Wild stocks			
Rangeeni (Ranchi)		48	115·5 ± 0·8
Rangeeni (Kundri)		17	110·0 ± 0·8
Kusmi (Madurai)		24	179·7 ± 4·6
Kusmi (Dharamjaigarh)		38	174·8 ± 2·1
Crosses			
Mother	Father		
Kusmi (Madurai)	*Rangeeni* (Ranchi)	21	117·0 ± 0·9
Kusmi (Dharamjaigarh)	*Rangeeni* (Kundri)	19	120·6 ± 1·4
Rangeeni (Ranchi)	*Kusmi* (Madurai)	42	142·3 ± 3·3
Rangeeni (Kundri)	*Kusmi* (Dharamjaigarh)	20	151·9 ± 8·9

It will be seen from Table 5 that the two strains differ distinctly in their life period and that this difference is genetic with the *rangeeni* phenotype showing dominance over the *kusmi*.

(Jawahir Lal and N. S. Chauhan)

Ecological studies on lac insects and associated insects

13. Studies on the effect of photoperiod on growth, life cycle, sex-ratio, fecundity and wing polymorphism

The effect of photoperiod was studied by maintaining two potted *bhalia* plants each under 24-hr exposure to natural light and 13, 10 and 7-hr exposures to the day light one to two weeks after their transplantation in July 1972. These plants were subsequently used for rearing the *katki* 1973 and *aghani* 1973-74 lac insects and the photoperiod treatment continued till the insects completed their

life cycle. Twenty-five isolated females were marked on each plant for their size, fecundity and resin dye-level.

The data now available for the *katki* 1972 insects have shown that the fecundity and the resin dye-level were reduced by about 74 and 40 per cent respectively under the 13-hr exposure compared to insects maintained under 24-hr exposure to natural light. The insects maintained under the 10- and 7-hr exposure failed to survive. The *baisakhi* 1972-73 and *jethwi* 1973 insects, however, have shown no such trend. In fact, the resin dye-level was found increased with the reduction in photoperiod.

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

14. Determination of the appropriate time of harvesting broodlac in different regions through the use of Biometer and thermograph records

With a view to developing a forecasting system for the crop maturity based on temperature records of the region concerned, the development of the *rangeeni* lac insect was studied at 27·5 and 30°C. The test insects were reared on potted plants of *vilaiti-babul* and maintained in an air-tight wooden cabinet fitted with a thermostat. The insects from the early and the last batches of larval emergence were used for this study.

The results obtained during the period under report have provided further evidence that the development of these insects is faster at 30°C than at 27·5°C.

(Beche Lal, B. P. Mehra and T. P. S. Teotia — Cooperator)

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

This study was taken up to provide basic information for the control of the inimical insects which are responsible for substantial losses in lac production. The method followed has been reported earlier (A.R., 1972). The average numbers of the inimical and beneficial parasites for the four lac crops raised during the period under report are shown in Table 6.

It will be seen from Table 6 that among the inimical parasites *Tetrastichus purpureus* was most abundant in the *baisakhi* 1972-73 and *aghani* 1973-74 crops and *Tachardiaephagus tachardiae* in the *jethwi* 1973. In the *katki* 1973 crop the relative position of these two parasites differed with the host used. Of the other inimical parasites, *Parechthrodryinus clavicornis* was particularly abundant in the *baisakhi* 1972-73 crop and *Coccophagus tschirchii* in the *katki* 1973. The peak period of the inimical parasites coincided with the periods of male emergence and crop maturity.

Among the lac predators, *Eublemma amabilis* and *Holcocera pulverea* were the most dominant. Their relative position, however, differed with the lac insect strain and host plant used. The peak period of the lac predators coincided with the time of crop maturity.

Of the beneficial parasites, *Bracon greeni* was the most abundant. *Elasmus claripennis*, although observed in low numbers, was recorded only from the rainy season crops. There was no emergence of *Brachymeria tachardiae* during the period under report.

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

TABLE 6 — AVERAGE NUMBERS OF THE INIMICAL AND BENEFICIAL INSECTS ASSOCIATED WITH LAC IN DIFFERENT CROPS AND ON DIFFERENT HOST SPECIES

Crop	Host	Inimical parasites								Predators		Beneficial parasites				
		Tetrastichus purpureus	*Tachardiaephagus tachardiae*	*Parechthrodryinus clavicornis*	*Coccophagus tschirchii*	*Erencyrtas dewitzi*	*Eutelmus tachardiae*	*Tachardiaephagus somervilli*	*Marietta javensis*	*Eublemma amabilis*	*Holcocera pulverea*	*Bracon greeni*	*Apanteles tachardiae*	*Elasmus claripennis*	*Brackymeria tachardiae*	*Pristomerus sulci*
Baisakhi 1972-73	*Palas*	235·00	2·33	25·60	3·66	2·33	0·33	0·00	0·66	32·66	64·33	2·33	2·00	0·00	0·0	1·33
	Bhalia	108·66	4·66	22·33	0·66	2·33	0·00	0·00	0·66	22·66	11·66	0·33	0·00	0·00	0·0	1·00
Jethwi 1973	*Kusum*	8·33	11·33	1·66	0·33	1·00	0·33	0·00	0·00	2·00	36·33	1·00	1·00	0·00	0·00	0·33
	Bhalia	22·00	47·66	0·00	0·00	0·00	0·00	0·00	0·66	1·66	3·66	1·33	1·33	0·00	0·00	1·00
Katki 1973	*Palas*	87·66	63·00	12·00	45·33	1·66	1·00	0·00	0·66	11·00	8·33	13·00	4·00	1·33	0·00	2·00
	Bhalia	8·00	24·66	0·33	11·00	0·33	0·00	0·00	0·00	5·66	1·00	2·00	1·33	0·33	0·00	0·00
Aghani 1973-74	*Kusum*	92·36	36·00	1·33	5·66	0·66	0·00	0·00	0·00	3·00	6·33	15·33	1·00	1·66	0·00	0·00
	Bhalia	122·66	39·00	3·00	5·33	0·33	0·66	0·00	0·00	1·66	4·33	20·00	1·66	1·66	0·00	0·66

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

The experiment was laid out on a randomized block design. *Palas* and *bhalia* were used for the *rangeeni* strain of lac insects and *kusum* and *bhalia* for the *kusmi* strain. The host plants were operated for maintenance of lac insect cultures on a four-coupe system for *kusum* and three-coupe system for the other hosts. The brood rates used to vary the lac insect density were 0·250, 0·500, 1·000 and 2·000 kg per tree for *kusum*, 0·125, 0·250, 0·500 and 1·000 kg per tree for *palas*, and 0·025, 0·050, 0·100 and 0·200 kg per plant for *bhalia*. Two plants were used for each brood rate for the tree host species and five for the bushy host (*bhalia*). The incidence of predators was studied from lac samples collected at two stages in the crop development, namely, at male emergence and crop maturity. For this purpose the lac samples were collected and caged in parasite cages in the laboratory for recording the emergence of predators. There was no emergence of predators from the samples collected at the time of male emergence. The emergence data for the samples collected at crop maturity are provided in Table 7. These results provide no consistent trend for any relation between the predator incidence and host density.

TABLE 7 — AVERAGE NUMBERS OF PREDATORS EMERGED FROM LAC SAMPLES COLLECTED AT CROP MATURITY FROM THE CROPS RAISED WITH VARYING BROOD RATES

Crop	Host	Brood rate (kg)	Predators		
			Eublemma amabilis	*Holcocera pulverea*	Total
Baisakhi (1972-73)	*Palas*	0·125	10	7	17
		0·250	12	6	18
		0·500	11	13	24
		1·000	12	10	22
	Bhalia	0·025	6	5	11
		0·050	7	4	11
		0·100	12	15	27
		0·200	0	0	0
Katki (1973)	*Palas*	0·125	2	1	3
		0·250	2	0	2
		0·500	2	5	7
		1·000	8	2	10
	Bhalia	0·025	2	1	3
		0·050	2	1	3
		0·100	5	5	10
		0·200	4	2	6
Jethwi (1973)	*Kusum*	0·250	19	65	84
		0·500	101	50	151
		1·000	31	38	69
		2·000	14	75	89
	Bhalia	0·025	45	11	56
		0·050	1	8	9
		0·100	1	10	11
		0·200	2	8	10

(B. N. Sah, Beche Lal, B. P. Mehra and T. P. S. Teotia)

17. Regional Field Research Station

The field research station at Dharamjaigarh (M.P.) continued to function during the period under report. The progress made under the various items of investigation is reported as below:

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

Two new cultivation schedules are being tried to improve upon the existing four-coupe system developed earlier at this Institute. These involve the use of one-year-old (Treatment A) and two-year-old (Treatment B) shoots for artificial inoculation in both the January and July seasons and raising the succeeding crop through self-inoculation for harvesting once in two crop seasons. The crop performance is compared with those of the standard four-coupe system involving the use of one and a half-year-old shoots with artificial inoculation and complete harvesting in each crop season (Treatment C) and the villagers' practice of keeping the trees continuously under lac through partial harvest in each crop season (Treatment D).

The crops could not be raised with the July inoculations due to non-availability of broodlac.

(b) *Investigation on likely alternative hosts to supplement production of kusmi lac in the region*

(i) *Trial on regional plant species as a kusmi host*

Jhera (*Ficus* sp.), *gular* or *dumar* (*Ficus recemosa*), *ruli-sindoor* or *rohri* (*Mallotus phillipinensis*), *salga* (*Boswellia serrata*) and *mahua* (*Madhuca indica*) were inoculated in January 1973 for raising the *jethwi* 1973 crop. Only *jhera* and *gular* carried sparse living cells at crop maturity in July which were left on the plants for self-inoculation.

The plant species referred to above along with *bargad* (*Ficus bengalensis*), *pipal* (*Ficus religiosa*) and *amaltas* (*Cassia fistula*) were inoculated in July 1973 for raising the *aghani* 1973-74 crop. Only *jhera*, *gular* and *bargad* have shown some survival of the insects.

(ii) *Introduction of lac hosts not naturally occurring in the region*

Attempts to raise a plantation of *bhalia* and *galwang* received a setback due to intense heat and termite attack.

(c) *General survey of the inimical and beneficial insects of the lac insect*

The survey could not be carried out as the crops were not raised due to non-availability of broodlac.

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

Integrated control of the enemies of lac insects

18. Field trials of an envisaged integrated control schedule against the lac predators

The study aims at integrating the control measures developed earlier against the lac predators to work out the most effective integrated control schedule. The control measures integrated were as follows:

W — Use of 60-mesh synthetic netting broodlac containers for crop inoculation (mechanical measure)

E — Use of 0·05 per cent Thiodan® (chemical measure)

B — Use of 0·05 per cent *Bacillus thuringiensis* preparation (microbial measure)

C — Use of mixture of E and B in equal proportion

Controls

N — No treatment

A — Spray with water

The sequence of the treatments in a particular crop is indicated by the order of the symbols used. Where the harvest was made after raising two successive crops and the treatments remained the same in each, the symbolic representation of the schedule is shown as multiplied by 2. Thus W $(EE)_2$ indicates that the crop was raised with the use of the mechanical measure and sprayed twice with Thiodan® in each crop. The efficacy of the control schedules was judged on the basis of yield and predator incidence. For the latter purpose, lac samples were collected at the time of crop maturity and caged in the parasite cages for noting the emergence of predators therefrom.

Aghani 1972-73 *crop on bhalia at Taimara*

The experiment was laid out on a randomized block design with the control plot separated from the others by a distance of about 150 metres. The control schedules tried were WEB, WC, WB, WE and W. Each schedule was tried on 10 bushes with 4 replications. The first spray was given three weeks after the crop inoculation and the second, where provided, three weeks thereafter. The data on yield and predator incidence are shown in Table 8.

TABLE 8 — AVERAGE LAC YIELD AND PREDATOR INCIDENCE WITH THE USE OF DIFFERENT CONTROL SCHEDULES

(Crop — *Aghani* 1972-73, date of inoculation — 21 July 1972; Host plant — *Bhalia*, date of harvesting — 9-11 January 1973; Locality — Taimara)

Treatment	Brood used (g)		Average yield per bush (g)						Average number of predators per 100 g stick lac	Reduction in predator number (%)
			Lac stick			Stick lac				
	Lac stick	Stick lac	Brood	Rejected	Total	Brood	Rejected	Total		
WEB	100	31·87	99·47	8·65	108·12	25·07	1·30	26·37	34·34	49·37
WC	100	32·50	41·83	9·42	51·25	7·27	1·25	8·52	21·71	67·99
WB	100	31·87	44·62	18·50	63·12	7·83	1·67	9·50	15·97	76·45
W	100	31·87	74·47	38·65	110·62	13·17	3·50	16·67	58·21	14·10
WE	100	33·12	93·45	10·92	104·37	23·30	1·72	25·02	43·35	36·09
N	100	32·23	26·87	22·50	49·37	6·05	2·20	8·25	67·83	—

Jethwi 1973 *crop on kusum at Taimara and at Institute plantation, Namkum*

The results were not available for the experiment carried out at Taimara due to theft of lac.

Fifteen control schedules were tried in the experiment carried out at the Institute plantation, Namkum. The results are furnished in Table 9.

TABLE 9 — AVERAGE LAC YIELD AND PREDATOR INCIDENCE WITH THE USE OF DIFFERENT CONTROL SCHEDULES

(Crop — *Jethwi* 1973, date of inoculation — 24-26 January 1973; Host plant — *Kusum*, date of harvesting — 10 July 1973; Locality — Institute plantation, Namkum)

Treatment	Brood used (kg)		Average yield per tree (kg)						Average number of predators per 100 g stick lac	Reduction in the predator number (%)
			Lac stick			Stick lac				
	Lac stick	Stick lac	Brood	Rejected	Total	Brood	Rejected	Total		
N	1·0	0·505	2·000	0·150	2·150	0·750	0·040	0·790	111·1	—
W	1·0	0·597	5·000	6·000	11·000	1·300	0·850	2·150	66·6	40·00
WA	1·0	0·623	2·000	2·750	4·750	0·600	0·485	1·085	83·3	25·04
WAA	1·0	0·575	5·000	2·500	7·500	0·750	1·000	1·750	41·8	62·28
WE	1·0	0·560	4·500	4·500	9·000	1·200	0·475	1·675	83·3	25·02
WEE	1·0	0·573	6·500	3·000	9·500	1·800	0·600	2·400	50·0	54·90
WEB	1 0	0·577	6·000	4·000	10·000	1·300	1·025	2·325	40·0	63·90
WEC	1·0	0·543	9·000	4·000	13·000	3·375	1·475	4·850	47·0	57·60
WB	1·0	0·580	10·500	—	10·500	3·230	—	3·230	96·0	13·59
WBB	1·0	0·595	1·000	2·500	3·500	0·500	0·725	1·225	16·6	85·05
WBC	1·0	0·585	10·000	3·500	13·500	1·830	0·575	2·405	16·2	85·41
WBE	1·0	0·555	8·500	1·000	9·500	3·500	0·400	3·900	46·25	58·28
WC	1·0	0·558	6·000	4·000	10·000	1·950	0·700	2·650	18·57	83·28
WCC	1·0	0·583	6·500	6·000	12·500	1·580	0·900	2·480	25·00	78·39
WCB	1·0	0·600	5·000	3·000	8·000	1·865	0·700	2·565	26·60	76·14
WCE	1·0	0·505	6·000	5·500	11·500	1·925	1·125	3·050	61·50	44·64

Jethwi 1973-*cum-aghani* 1973-74 *crop on kusum at the Institute plantation, Namkum*

Fifteen control schedules were tried. In the *jethwi* 1973 crop the first spray was given 10 weeks after inoculation and the second, where provided, 9 weeks thereafter. This crop was partially harvested in July using the remaining broodlac on the trees for self-inoculation. In the following *aghani* 1973-74 crop, the first spray was given 7-8 weeks after settlement and the second, where provided, two weeks thereafter. The yield data are provided in Table 10.

Baisakhi 1972-73-*cum-katki* 1973 *crop on palas at Lota*

Fifteen control schedules were tried, but the results were not available due to theft of lac.

It will be seen from Tables 8 and 9 that the control schedules tried resulted in suppression of the predators and substantial increase in the lac yield. However, the yield improvements have not been proportionate to the degree of predator suppression. The lac yields in these experiments would also appear to be rather subnormal.

(R. C. Mishra, C. P. Malhotra and T. P. S. Teotia — Cooperator)

TABLE 10 — AVERAGE LAC YIELD WITH THE USE OF DIFFERENT CONTROL SCHEDULES

(Crop — *Jethwi* 1973-cum-*aghani* 1973-74; date of inoculation — 26 January 1973; Host plant — *Kusum*; date of harvesting — Partial 13-15 July 1973; Complete 24-26 Feb. 1974; Location — Institute Plantation, Namkum)

Treatment	Brood used (kg)		Average yield per tree (kg)					
			Lac stick			Stick lac		
	Lac stick	Stick lac	Brood	Rejected	Total	Brood	Rejected	Total
N	1·000	0·500	1·000	1·570	2·570	0·320	0·187	0·507
W	1·000	0·512	2·000	4·725	6·725	0·480	1·125	1·605
W(A) 2	1·000	0·481	1·500	4·250	5·750	0·290	1·037	1·327
W(AA) 2	1·000	0·491	3·125	5·725	8·850	1·000	0·725	1·725
W(E) 2	1·000	0·555	2·075	4·975	7·050	1·275	1·005	2·280
W(EE) 2	1·000	0·442	9·300	5·350	14·650	2·657	1·538	4·195
W(EB) 2	1·000	0·493	2·050	5·250	7·300	1·300	0·725	2·025
W(EC) 2	1·000	0·514	3·425	6·400	9·825	1·425	1·450	2·875
W(B) 2	1·000	0·546	1·125	3·650	4·775	0·412	0·750	1·162
W(BB) 2	1·000	0·506	3·150	7·500	10·650	1·215	2·037	3·252
W(BC) 2	1·000	0·479	2·575	3·825	6·400	1·037	0·787	1·825
W(BE) 2	1·000	0·556	3·600	4·250	7·850	1·022	0·750	1·772
W(C) 2	1·000	0·524	3·825	6·700	10·525	1·860	1·275	3·135
W(CC) 2	1·000	0·525	3·800	4·575	8·375	1·850	1·405	3·255
W(CB) 2	1·000	0·482	3·625	3·325	6·950	1·170	0·875	2·045
W(CE) 2	1·000	0·550	5·900	8·100	14·000	1·877	2·218	4·095

19. Evolving cultural control for the enemies of lac insect

(i) *Finding out a cheap broodlac container for crop inoculation*

Further studies confirmed the finding reported earlier (A.R., 1972) that 60-mesh synthetic netting container was as effective as that of the brass wire-netting, reducing the cost by about 70 per cent.

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

(ii) *Trap cropping*

The idea of studying the use of a trap crop as a pest control measure is based on the observations made earlier that the incidence of most destructive lac predator *Eublemma amabilis* is dependent on the host (lac insect) density. Thus an experiment was laid out on *palas* in the Forest Lac Orchard at Kundri (Palamau) in which the main *baisakhi*-cum-*katki* crop was raised with light inoculation at the rate of 200 g broodlac per tree along with a trap crop heavily inoculated at the rate of 1 kg broodlac per tree. The trap crop was harvested as *ari* in the following May for commercial lac and destruction of the trapped predators. The distribution of the main and trap crops was studied in the following design:

A — Use of the trap crop as a border for the main crop
B — The two crops are raised in alternate strips
C — The trees carrying the trap crop are interspersed among those carrying the main crop
D — The main crop is raised without a trap crop (control)

Twenty-five trees were used for each of the main and trap crops with four replications. The incidence of the predators was studied once at the time of

ari harvesting in May based on one metre lac stick sample and again at the time of the final harvest of the main crop in October based on the emergence of predators per 100 g matured sticklac.

Consideration of the yield and predators data set out in Table 11 will show that the incidence of only *E. amabilis* was lower in the main crops raised along with a trap crop with yield improvements in two of the three crops so raised, suggesting effectiveness of the use of a trap crop as a crop improvement measure. This, however, is not supported by the trap crop data which show that the predator was probably trapped only in one of the three distributional designs of the two crops studied.

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

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

The effect of varying the time of crop inoculation on the incidence of the predators and crop yield was continued to be studied on *palas* at the Forest Lac Orchard at Kundri by raising the *baisakhi* 1973-74 crops with the local and Ranchi broodlacs which provided the lac larvae at different times. The crops are in progress.

To further shift the period of crop inoculation, arrangements are being made for the procurement of broodlacs from the other lac growing regions of the country also.

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

(iv) *Effect of exposure of lac to the sun*

The broodlac from the *katki* 1973 crop was spread on a cemented floor in the sun for two hours from 10.00 hr to 12.00 hr and the predators contained therein examined. This treatment was found to kill almost all the caterpillars of *Eublemma amabilis* and *Holcocera pulverea*, but also adversely affected the matured female lac insects and their progenies.

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

20. Evolving mass rearing techniques for important beneficial parasites on alternate hosts for inundative releases in field trials and their behavioural studies

The most promising parasite of the lac predator *Holcocera pulverea*, namely, *Apanteles tachardiae* Cameron was mass reared in the laboratory on *Corcyra cephalonica* during July to September for release in a *kusmi* area at Dasong. About 12,000 adult parasites were bred, but these could not be released due to theft of the crop raised for this purpose.

(C. P. Malhotra and P. Sen)

Exploratory studies on the application of modern pest control technology against the predators of lac insect

21. Laboratory screening of antifeedants and repellants against major lepidopterous predators

Brestan® and Brestanol® in concentrations ranging between 0·1 and 0·3 per cent were tested for their safety to the 4, 10, 20 and 40-day-old lac insects maintained on potted *bhalia* plants in the *baisakhi* 1972-73 and *jethwi* 1973 seasons. No adverse effect has been noted in any case.

TABLE 11 — THE AVERAGE YIELD AND NUMBER OF PREDATORS IN THE TRAP AND MAIN CROPS

(Crop — Trap crop, *baisakhi* 1972-73 *ari*; Main crop — *baisakhi* 1972-73-cum-*katki* 1973; date of inoculation, 13-17 November 1972; date of harvesting, Trap crop, 5-7 May 1973, Main crop, 10-24 October 1973; Host plant — *Palas*; Locality — Kundri)

Crop	Brood used (kg)		Average yield per tree (kg)								Month	Average number of predators	
			Lac stick				Stick lac						
	Lac stick	Stick lac	Brood	Rejected	*ari*	Total	Brood	Rejected	*ari*	Total		*Eublemma amabilis*	*Holcocera pulverea*
Alternate strips													
(i) Trap	1·00	0·085	—	—	1·985	1·985	—	—	0·216	0·216	May	0·50	0·75*
(ii) Main	0·20	0·025	0·276	0·182	—	0·458	0·056	0·011	—	0·067	May	0·00	1·50*
											Oct.	24·60	94·80†
Interspersed													
(i) Trap	1·00	0·090	—	—	1·750	1·750	—	—	0·217	0·217	May	0·50	0·50*
(ii) Main	0·20	0·024	0·310	0·180	—	0·490	0·073	0·020	—	0·093	May	0·00	0·25*
											Oct.	14·55	74·40†
Border													
(i) Trap	1·00	0·097	—	—	2·370	2·370	—	—	0·224	0·224	May	1·00	1·00*
(ii) Main	0·20	0·022	0·332	0·158	—	0·490	0·076	0·023	—	0·099	May	0·25	0·25*
											Oct.	9·85	96·64†
Control													
Main	0·20	0·027	0·240	0·180	—	0·422	0·055	0·011	—	0·066	May	0·50	0·75*
											Oct.	33·61	93·19†

*Av. Number of predators per metre length of lac sticks.
†Av. Number of predators per 100 g scraped lac.

Newly hatched caterpillars of *Eublemma amabilis* and *Holcocera pulverea* were released on lac insects treated with Brestan® and Brestanol® in concentrations found safe for the lac insects. The predatory caterpillars were observed to orient away from the food source after the initial bite. The per cent inhibition of feeding of *E. amabilis* caterpillars varied from 46·6 to 65·0 with Brestan® and from 38·3 to 58·3 with Brestanol®. The per cent inhibition of feeding of *H. pulverea* caterpillars were 40-60 and 35-65 respectively.

(S. G. Choudhary, T. P. S. Teotia and C. P. Malhotra — Cooperator)

22. Laboratory evaluation of the efficacy of the microbial agents for the control of lepidopterous predators

Three commercial preparations of *Bacillus thuringiensis*, namely, Thuricide®, Dipel® and Biotrol® were tried at 16,000 IU/mg against the caterpillars of *Eublemma amabilis*. The per cent mortality noted were 81·30, 82·06 and 75·60 with Thuricide®, Dipel® and Biotrol® respectively.

A fungal preparation obtained from the Nutrilite Products, California was tried against the caterpillars of *E. amabilis* and *H. pulverea*, which proved ineffective against both.

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

23. Relative toxicity of newer synthetic insecticides and plant poisons to lepidopterous predators of the lac insect

Bioresmethrin was tried in concentrations ranging between 0·003 and 0·015 per cent for its safety to the 12-day-old lac insects but proved toxic with 44·5 per cent mortality at the lowest concentration tried.

Similar trials with the emulsifiers Dedenol Super N, Polysorbate 80 and Hyoxid X 100 at 0·05 per cent concentration, however, showed that they are safe to the 12-day-old lac insects.

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

(c) RESEARCHES CONTEMPLATED

The following problems are to be included in the next year's programme:

1. Studies to evolve a suitable method for producing lac on *bhalia* (*Moghania macrophylla*) regularly during both the seasons (at Amjharia).
2. Evolution of a schedule for *rangeeni* lac cultivation on *galwang* and *ber* bushes in alternation.
3. Bio-ecological aspects of *Pristomerus sulci*, an endoparasite of *Holcocera pulverea*, a predator of lac insect, *Kerria lacca* Kerr.
4. Studies on the effect of insecticidal control of the major lac predators on the vital and economic attributes of the lac insect and its associated fauna.
5. Estimation of losses caused by the enemy insects of lac.
6. Inheritance of white lac in lac insects.

B. AGRONOMY AND PLANT GENETICS DIVISION

(a) RESEARCHES COMPLETED

Studies on various vegetative propagation methods

Lac-hosts show wide individual differences within the same species in respect of their capacity to sustain lac insects, thereby affecting regular lac production. A trial was, therefore, initiated in 1969 to propagate potential lac-hosts from stem cuttings with the help of growth regulators, as practised in forestry and horticulture, for obtaining plants of desired characters and multiply them within a short period.

The investigation was carried out on *palas*, *kusum*, *galwang*, *bhalia*, *sandan*, *pansaura* (*Grewia serrulata*) and *rain tree* in 4 different seasons of January, March, June and September. The growth regulators tried were indole butyric acid, α-napthalene acetic acid, indole propionic acid and indole acetic acid in various combinations at 50 and 100 ppm. Of the host species tried, *bhalia*, *galwang*, *pansaura* and *rain tree* were successfully raised from stem cuttings using growth regulators while the other hosts did not develop roots at all. The stem cuttings in the control (no treatment) failed to produce any roots in all cases.

The performance on the rooting response of the host species varied with the growth regulator mixtures and their concentration (Table 12). Of the 3 mixtures tried on *galwang* and *bhalia*, IBA+IPA at 100 ppm was found best for *galwang* and IPA+NAA at 50 ppm for *bhalia*. Similarly, of the 3 mixtures tried on rain tree and *pansaura*, IAA+NAA at 100 ppm for rain tree and IBA+IAA at 50 ppm for *pansaura* proved best in establishing large number of rooted plants. Callus formation in the established cuttings of all the 4 host species was quite satisfactory with a fibrous and well branched root system.

The March planting was most successful for *galwang* and June planting for *bhalia*, rain tree and *pansaura* in establishing the rooted plants.

TABLE 12 — ROOTING RESPONSE OF LAC-HOST CUTTINGS WITH GROWTH REGULATORS AND THEIR SEASONAL EFFECT

Growth regulators	Concentration (ppm)	Average rooted plants (%)			
		Jan.	Mar.	June	Sept.
		Albizzia lucida			
IBA + IPA	50	20	50	30	20
	100	10	60	40	10
IBA + NAA	50	0	20	10	0
	100	0	10	20	0
IPA + NAA	50	0	30	0	0
	100	10	30	20	0
		Moghania macrophylla			
IBA + IPA	50	20	20	60	30
	100	0	10	30	20
IBA + NAA	50	0	20	80	40
	100	0	0	20	10
IPA + NAA	50	20	40	100	60
	100	0	30	40	20

TABLE 12 — ROOTING RESPONSE OF LAC-HOST CUTTINGS WITH GROWTH REGULATORS AND THEIR SEASONAL EFFECT — *contd.*

Growth regulators	Concentration (ppm)	Average rooted plants (%)			
		Jan.	Mar.	June	Sept.
		Samanea saman			
IBA + IAA	50	0	10	20	0
	100	0	10	10	0
IBA + NAA	50	0	10	20	20
	100	0	20	30	10
NAA + IAA	50	0	20	50	20
	100	0	40	70	20
		Grewia serrulata			
IBA + IAA	50	0	20	50	0
	100	0	20	40	0
IBA + NAA	50	0	10	20	10
	100	0	30	30	10
NAA + IAA	50	0	10	10	10
	100	0	0	10	0

(b) RESEARCHES ON HAND

1. Utilization of *arhar* for lac cultivation

Eighty varieties of *arhar* were sown in July 1973 and inoculated in October with *rangeeni* strain of lac insects. Almost all the varieties took larval settlement and the development of insects was satisfactory on the medium and long duration varieties till the end of the period under report.

(Sohan Lal and P. Kumar)

2. Integrating lac cultivation with general land use pattern: Intercropping of lac-host shrubs with intensive crop rotations under irrigated conditions

Experiments on intercropping of two lac-host shrubs, namely, *bhalia* and *arhar* with three intensive crop rotations, i.e. groundnut-wheat-*baisakhi moong*, potato-wheat-*baisakhi moong* and groundnut-sugarcane were laid out.

(a) *Intercropping of arhar*

The intercrop of *arhar* was grown, with and without lac, in the aforesaid rotations. *Arhar* plants were inoculated with *rangeeni* lac insects in October 1973, and the growth of the insects was found satisfactory. Due to intercropping of *arhar* no marked reduction was noted in the yield of groundnut crop.

(b) *Intercropping of bhalia*

The *bhalia* bushes grown as an intercrop also did not exercise any apparent adverse effect on the groundnut crop.

(Sohan Lal)

3. Occurrence and utilization of *Rhizobia* in lac-host plants

The rhizobia from the root nodules of *M. macrophylla* and *M. chappar* were isolated and their growth habits studied. It was observed that *M. chappar* developed more nodules in the roots than *M. macrophylla*. Further, the rhizobium of *M. chappar* was found to be more fast growing than that of *M. macrophylla*.

(Sohan Lal and P. Kumar)

4. Introduction of rain tree for lac cultivation

(i) *Growing of rain tree under fertilized and irrigated conditions*

The study aims at determining the optimum manurial and irrigation requirements during the early growth stage of the plants for their quick and vigorous growth for early lac inoculation.

The experiment is laid out on a split-plot design, with the following treatments and 4 replications, each sub-plot consisting of 4 plants in a row.

(a) Manurial treatments (Main plots)

M_1 — NPK at planting in June

M_2 — NPK at planting in June and in September

M_3 — NPK at planting in June, September and in March in following year

M_4 — NPK at planting in June, September and in March and June in following year

M_5 — NPK and Farm yard manure at planting

(b) Levels of irrigation (Sub-plots)

I_0 — No irrigation

I_1 — Weekly irrigation

I_2 — Fortnightly irrigation

I_3 — Monthly irrigation

The nutrients (NPK) are supplied in the form of urea, super-phosphate and muriate of potash at the rate of 50, 100 and 25 g per plant respectively, and irrigation given only during the summer months from March to June.

During the period under report, the seedlings raised in nursery beds were transplanted in their respective plots towards the end of June and their growth has been satisfactory.

(ii) *Growing of rain trees into bushes*

The object of this trial is to grow rain tree into bushes for introducing intensive cultivation of lac on a plantation basis at reduced costs. Under this experiment, three factors, namely, spacing, height and time of coppicing are studied. The experiment is laid out on a split-plot design with the following treatments and 4 replications:

(a) Spacing (Main plot)

(i) 1·8 m × 1·8 m (S_1)

(ii) 1·8 m × 2·7 m (S_2)

(iii) 1·8 m × 3·6 m (S_3)

(b) Height of coppicing (Sub-plot)
  (i) At 15 cm (H_1)
  (ii) At 30 cm (H_2)
  (iii) At 45 cm (H_3)

(c) Time of coppicing (Sub-plot)
  (i) March (M_1)
  (ii) May (M_2)
  (iii) At harvest in July (M_3)

The experiment has been initiated in 1973 and the plants transplanted in July have shown satisfactory growth.

(B. K. Purkayastha)

5. Role of plant growth regulators on the growth of plants

(i) *Influence of pre-treatment of Moghania macrophylla seeds with growth regulators in relation to lac yield*

Under this experiment, initiated in March 1973, *Moghania macrophylla* seeds were treated with growth regulators, naphthalene acetic acid and Gibberellic acid, at 4 different concentrations of 10, 20, 40 and 80 ppm for 24 hr and then sown in nursery beds. The seedlings thus raised were transplanted in the respective plots comprising of 9 treatments replicated 4 times.

The performance on the growth of the plants with respect to shoot length per plant was found best in plants raised from seeds treated with NAA at 80 ppm (686·7 cm) as compared to the control (343·2 cm).

(ii) *Effect of Gibberellic acid on the growth of plants*

The need to establish mixed plantations of *A. lucida* and *M. macrophylla* within a short period, providing satisfactory shoots for inoculation of lac, is keenly felt. In order to achieve this objective, a trial was undertaken to study the effect of GA — a growth promoter, on these bushy host plants in relation to lac yield.

The host plants, *A. lucida* and *M. macrophylla*, were planted in respective plots by transplanting nursery-raised seedlings in July 1973. GA in the form of foliage spray at 20, 40 and 80 ppm was applied to the growing tips at the initial stage, after transplantation, for three successive periods at fortnightly intervals. A set of plants was kept as the control (water-spray).

The application of GA with different concentrations has increased the height of both the host plants significantly over the control. The growth was best at 80 ppm in *A. lucida* (71 cm) and at 40 ppm in *M. macrophylla* (89·6 cm), showing an increase of 125·0 per cent and 30·0 per cent respectively, over the control.

(B. K. Purkayastha)

6. Cyto-taxonomic and mutation studies in lac-host plants

(a) *Cyto-taxonomic studies*

The karyotype studies in some more varieties of *C. cajan* and of *Albizzia lucida*, *A. lebbek*, *Acacia catechu* and *S. saman* were completed, and the somatic

chromosome numbers were confirmed as 2n = 22, 26, 26, 26 and 26 respectively. The detailed studies on chromosome morphology of different varieties of *C. cajan*, as summarized in Table 13, showed morphological differences amongst themselves although their chromosomes have been recorded as 2n = 22.

TABLE 13 — MEASUREMENTS OF SOMATIC CHROMOSOMES OF VARIOUS LAC-HOST PLANTS AND THIRTEEN VARIETIES OF *C. cajan*

Sl. No.	Name of the plants	Diploid chromosome number (2N)	Total chromatin length (μ)	Range of chromosome length (μ)	Range of arm ratio
	Cajanus cajan (varieties)				
1	T-1	22	48·4	1·8-2·6	1·06-1·43
	NP 41	22	51·2	2·0-2·7	1·01-1·47
	NP 39	22	45·0	1·5-2·5	1·01-1·90
	NP 80	22	42·3	1·5-2·5	1·04-2·18
	BR 60	22	45·2	1·3-2·5	1·01-1·70
	Assam	22	46·0	1·5-2·5	1·01-2·00
	Motihari	22	36·2	1·0-2·1	1·01-1·90
	Ranchi	22	35·4	1·0-2·0	1·01-2·00
	7 S	22	44·8	1·5-2·5	1·22-1·65
	C 11	22	47·0	1·8-2·6	1·06-1·38
	No. 148	22	49·0	1·5-2·9	1·02-2·00
	PT 301	22	47·2	1·4-3·0	1·20-2·33
	ILRI	22	40·2	1·0-2·5	1·18-2·02
2	*Moghania macrophylla*	22	37·2	1·0-2·2	1·08-2·16
3	*M. chappar*	22	39·2	1·4-2·0	1·00-2·31
4	*Dalbergia lanceolaria*	20	42·0	1·5-2·8	1·05-2·15
5	*Acacia catechu*	26	41·6	1·0-2·2	1·12-2·26
6	*Samanea saman*	26	33·0	0·9-1·8	1·00-2·00
7	*Albizzia lucida*	26	49·8	1·4-2·5	0·50-1·00
8	*A. lebbek*	26	46·8	1·4-2·2	0·50-2·00
9	*Butea monosperma*	18	41·4	2·0-3·0	1·02-2·00

The meiotic studies in two more varieties of *C. cajan*, viz., PT 301 and ILRI were completed this year. The half chiasma per chromosome were calculated by taking the average of ten metaphase I plates in thirteen varieties of *C. cajan*, *M. macrophylla*, *M. chappar*, *Dalbergia lanceolaria* and *B. monosperma*. The data on detailed meiotic studies have been shown in Table 14. In order to determine the inter- and intra-class correlation amongst thirteen varieties of *C. cajan*, the partial analysis of variance of chiasma frequency within and between nuclei was applied, and it was observed that there was positive correlation amongst all the varieties except varieties Assam, 7-S and ILRI, where negative correlation was noted (Table 15).

(b) *Mutation studies*

The mitotic abnormalities in root and shoot tips of germinated seeds (irradiated by gamma rays at doses ranging from 10 to 40 krs) of two varieties of *C. cajan* (Ranchi and Assam) and two species of *Moghania* (*M. macrophylla* and *M. chappar*) were studied. It was observed that mitotic aberrations, such as, bridges and fragments per anaphase-telophase and micronuclei per interphase in root and shoot meristems increased with dose and decreased with lapse of time.

(b) Height of coppicing (Sub-plot)
- (i) At 15 cm (H_1)
- (ii) At 30 cm (H_2)
- (iii) At 45 cm (H_3)

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	7 S	22	44·8	1·5-2·5	1·22-1·65
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	No. 148	22	49·0	1·5-2·9	1·02-2·00
	PT 301	22	47·2	1·4-3·0	1·20-2·33
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TABLE 14 — CHROMOSOME PAIRING AND CHIASMA FREQUENCY IN LAC-HOST PLANTS

Name of the plant	Bivalents				Total bivalents	Chiasmata per PMC		Terminalized chiasmata per PMC		Half chiasma per chromosome	Terminalization co-efficient
	Ring		Rod			Range	Mean	Range	Mean		
	Range	Mean	Range	Mean							
1. *Cajanus cajan*											
Var. T-1	3-11	7·43	0-8	3·52	11	14-25	20·40	15-22	17·80	0·92	0·87
Var. NP 41	4-11	8·66	0-7	2·33	11	17-28	23·20	13-21	18·55	1·05	0·75
Var. NP 39	7-11	10·00	0-4	1·00	11	22-31	28·54	12-22	19·09	1·29	0·66
Var. NP 80	7-11	8·83	0-4	2·16	11	22-30	24·83	13-20	17·75	1·12	0·37
Var. BR 60	8-11	9·10	0-3	1·90	11	23-30	25·30	17-22	19·40	1·15	0·76
Var. Assam	8-11	10·26	0-3	0·73	11	21-27	25·26	19-22	20·80	1·14	0·82
Var. Motihari	9-11	10·50	0-2	0·50	11	26-33	30·90	21-22	21·60	1·40	0·69
Var. Ranchi	1-11	8·77	0-11	2·22	11	20-28	26·11	19-22	20·77	1·18	0·78
Var. 7 S	9-10	9·30	1-2	1·70	11	21-24	22·90	18-22	19·60	1·04	0·85
Var. C 11	—	11·00	0-0	0·00	11	21-33	30·72	20-22	20·81	1·08	0·67
Var. 148	8-11	10·20	0-3	0·80	11	25-31	29·90	17-22	19·80	1·35	0·66
Var. PT 301	7-10	8·00	1-4	3·00	11	21-26	23·90	13-20	15·45	1·04	0·66
Var. ILRI	8-11	9·10	0-3	1·90	11	19-30	22·70	19-22	16·50	1·03	0·72
2. *M. macrophylla*	7-11	9·20	1-4	1·80	11	18-24	21·60	14-20	17·70	0·98	0·82
3. *M. chappar*	8-11	10·80	0-3	0·15	11	21-28	25·05	16-22	21·60	1·13	0·86
4. *D. lanceolaria*	8-10	9·30	0-2	0·70	10	21-25	23·10	15-20	17·40	1·05	0·73
5. *B. monosperma*	8-9	8·50	0-1	0·50	9	17-22	20·00	16-18	17·00	1·11	0·88

TABLE 15 — ANALYSIS OF VARIANCE OF CHIASMA FREQUENCY IN THIRTEEN VARIETIES OF *C. cajan*

Sl. No.	Source of variation	Mean chiasmata per PMC	Mean square between nuclei	Mean square within nuclei	Variance ratio	Level of significance	v value
1	Var. T-1	20·4	0·690	0·329	0·47	N.S.	0·0931
2	Var. NP 41	23·2	0·950	0·490	0·51	N.S.	0·0702
3	Var. NP 39	28·5	0·697	0·384	0·55	N.S.	0·5592
4	Var. NP 80	24·8	0·591	0·589	0·99	N.S.	0·0072
5	Var. BR 60	25·3	0·687	0·549	0·79	N.S.	0·0114
6	Var. Assam	25·2	0·252	0·352	1·39	N.S.	—0·0310
7	Var. Motihari	30·9	0·231	0·229	0·99	N.S.	0·0084
8	Var. Ranchi	26·1	0·576	0·450	0·78	N.S.	0·0122
9	Var. 7S	22·9	0·109	0·432	3·97	S.	—0·0756
10	Var C11	33·8	0·888	0·445	0·50	N.S.	0·0874
11	Var. 148	29·9	0·201	0·162	0·81	N.S.	0·0114
12	Var PT 301	23·09	0·453	0·341	0·75	N.S.	0·0173
13	Var. ILRI	22·7	0·370	0·710	1·92	N.S.	—0·0502

The gamma irradiated seeds of *M. macrophylla* and *M. chappar*, along with the control, were kept for germination in petridishes under laboratory conditions. The root and shoot lengths were measured for seven days. The observations showed that the average root and shoot lengths decreased with increase of dose.

The observations on various plant attributes, such as, height, number of primary branches and total shoot length per plant of M_1 generation plants of two varieties of *C. cajan* (Ranchi and Assam) raised from gamma irradiated seeds showed that they decreased with increase of dose.

Meiotic aberrations in the flower buds of M_1 generation plants raised after gamma irradiation of seeds of both the *arhar* varieties (Ranchi and Assam) were found to increase with the increase of dose.

The changes in various plant attributes of *bhalia* and *salpan* observed in M_1 generation after gamma irradiation of seeds showed that in M_2 generation the plants returned towards normality at lower dose levels but at higher doses the abnormalities still persisted.

(P. Kumar)

(c) RESEARCHES CONTEMPLATED

Lac cultivation on *bhallia* (*Moghania macrophylla*).

C. CHEMISTRY DIVISION

(a) RESEARCHES COMPLETED

1. Polyesterification of aleuritic acid derivatives

The kinetics of self-esterification and molecular weight-intrinsic viscosity relationship of the polyesters of trans-16-hydroxy-enoate-hexadecanoic acid were reported earlier (A.R., 1972). During this year, polymolecularity of one

polyester having A. V. 56·00 (mol. wt. 1000 by end group) derived from trans-16-hydroxy-9-enoate-hexadecanoic acid was studied. Besides, uncatalysed and catalysed kinetics, molecular weight-intrinsic viscosity relationship and polymolecularity of 16-hydroxy palmitic acid or juniperic acid were also studied.

Fractionation of trans-16-hydroxy-9-enoate-hexadecanoic acid polyester

One per cent solution of the polymer of acid value 56·00 was prepared in pure dry acetone, 100 ml solution was taken and it was fractionated (at 30°C) into seven fractions with water as non-solvent. The experimental data, namely, weight of each fraction, acid value and molecular weight of each fraction by end group analysis are given in Table 16.

Distribution curves

These curves were constructed according to Tung's function [*J. Polym. Sci.*, **20** (1956), 495].

The integral curve in this work is represented by the equation $I(x) = 1-e-axb$ where $I(x)$ is cumulative weight fraction, x the molecular weight and a and b are constants.

On differentiation, the integral equation gives the differential weight distribution function as

$$dI(x)/dx = ab^{e-axb}xb-1$$

The values of constants a and b were obtained by plotting log {log $1/[1-I(x)]$} against log of molecular weight.

Integral weight distribution curve

This curve was constructed by plotting cumulative weight fraction $I(x)$ against molecular weight (Table 16). The curve was found as usual 'S' shaped.

TABLE 16 — FRACTIONATION DATA OF TRANS-16-HYDROXY-9-ENOATE-HEXADECANOIC ACID POLYESTER

(The fraction numbers are given in the reverse order as they were obtained in the experiment)

Fraction No.	Wt of each fraction	Acid value	Cumulative wt fraction $I(X)$	$\frac{dI(x)}{dx} \times 10^5$	Mol. wt
1	0·1050	125·20	0·0613	17·54	448·1
2	0·1104	64·74	0·1872	52·92	866·5
3	0·1030	53·28	0·3118	66·50	1053·0
4	0·1024	46·11	0·4318	73·62	1217·0
5	0·1000	38·28	0·5500	72·76	1465·0
6	0·2746	32·07	0·7688	56·34	1749·0
7	0·0606	29·48	0·9645	43·89	1903·0

Differential weight distribution curve

To construct this curve, the values of constants like a ($5·012 \times 10^{-10}$) and b (2·92) were first obtained by plotting log of log $1/1-I(x)$ *vs* log M and from this

corresponding value of $dI(x)/dx$ were calculated and are given in Table 16. From the data the differential curve was drawn and maxima and minima obtained. The maxima indicate the abundant species available in the present sample, which was found to be in the range of molecular weight about 1200.

Kinetics, molecular weight-intrinsic viscosity relationship and polymolecularity of juniperic acid

Uncatalysed and catalysed kinetics — The experimental arrangement was essentially the same as described by Bhattacharya [*J. scient. ind. Res.*, **11B**, No. 12 (1952), 512-20]. The uncatalysed and catalysed (0·2% *p*-toluene sulphonic acid) kinetics were studied at 120°, 140°, 160° and 180°C. The order of reactions were third and second and activation energies 20·52 k.cal/mole and 10·43 k.cal/mole respectively. It was also noticed that in later stage after attaining 93 per cent conversion, the product became insoluble in all the common solvents.

Intrinsic viscosity-molecular weight relationship

Four samples of polyesters were drawn at 180°C after 0·5, 2·0, 4·0 and 9·0 hr respectively. The experimental data, namely, melting point, acid value, intrinsic viscosity and molecular weight of the samples are given in Table 17.

TABLE 17 — PROPERTIES OF VARIOUS POLYESTERS FROM JUNIPERIC ACID

Sample No.	m.p. °C	Acid value	[*n*] in chloroform at 25°C	Mol. wt by end group
1	82-83	89·8	0·060	624·7
2	88-89	46·7	0·105	1201·0
3	89-90	25·9	0·192	2166·0
4	90-91	21·6	0·216	2597·0

On plotting the log [*n*] *vs* log $\bar{M}n$ (obtained by end group), a straight line was obtained. The value of K was calculated from the intercept and from the slope of the straight line. The relationship was found to be as follows:

$$[n] = [12{\cdot}50 \times 10^{-5} M^{0{\cdot}95}] \text{ chloroform } 25°C$$

Polymolecularity — The polyester which was subjected for the fractionation had acid value 22·20 and molecular weight 2527 determined by end group method. Polymer solution (1 per cent) was prepared in pure benzene and fractionated into five fractions with methanol as non-solvent at 32°C. The experimental data, namely, weight of each fraction, acid value and molecular weight by end group analysis are listed in Table 18.

Distribution curves — These curves were constructed as described in the case of trans-16-hydroxy-9-enoate-hexadecanoic acid polyester. The experimental data are given in Table 18. The integral curve here was also found to be characteristic 'S' shaped. In case of differential curve, the values of *a* and *b*

TABLE 18 — FRACTIONATION DATA OF 16-HYDROXY PALMITIC ACID POLYESTER

(The fraction numbers are given in the reverse order as they were obtained in the experiment)

Fraction No.	Wt of each fraction	Acid value	Cumulative wt fraction $I(x)$	$\frac{dI(x)}{dx} \times 10^5$	Mol. wt
1	0·0890	43·05	0·0585	14·63	1303
2	0·0852	37·45	0·1730	19·13	1498
3	0·1084	21·20	0·3003	39·78	2646
4	0·1536	19·11	0·4725	39·34	2935
5	0·3244	15·70	0·7867	28·98	3573

were $7{\cdot}943 \times 10^{-12}$ and 3·18 respectively. The maxima in the curve was found at the region of the molecular weight about 2600.

(P. C. Gupta and P. R. Bhattacharya)

2. Grafting of shellac with vinyl monomers

Last year the grafting of shellac with methyl methacrylate (MMA) was studied using hydrogen peroxide as initiator. This year graft copolymers of shellac with vinyl monomers were prepared using different initiators, namely: (i) benzoyl peroxide, (ii) hydrogen peroxide and ferrous ammonium sulphate, (iii) ceric ammonium nitrate, (iv) potassium persulphate, (v) cumene hydroperoxide and (vi) cumene hydroperoxide and ferrous ammonium sulphate.

In the case of benzoyl peroxide and hydrogen peroxide/ferrous ammonium sulphate, the products obtained by copolymerizing shellac and methyl methacrylate had similar solubility behaviour as the one obtained by using hydrogen peroxide alone.

In the case of ceric ion, no grafted product could be isolated.

Copolymerization of shellac with ethyl acrylate using potassium persulphate was carried out in triethanolamine and water for 6 hr at 90°-98°C. In this case also, no grafting was noticed.

Grafting of shellac with MMA was next tried using cumene hydroperoxide as initiator. In the first experiment only cumene hydroperoxide was used while in the second a mixture of cumene hydroperoxide and ferrous ammonium sulphate was used. The polymerization was carried out by taking aqueous ammoniacal solution of shellac and allowing the reaction to proceed at 98°C for 3 hr. The product was precipitated with acetic acid, washed, filtered and dried. It was subsequently washed with toluene and alcohol to remove homopolymer and unreacted shellac.

In both cases, the product behaved similar to the product which was obtained by copolymerization of shellac and MMA using hydrogen peroxide as initiator.

The IR spectra of both the products are being taken.

(K. M. Prasad and P. R. Bhattacharya)

3. Modification of shellac with epichlorohydrin

It was reported earlier (A.R., 1972) that when dewaxed shellac was reacted with epichlorohydrin (at 70-80°C) in presence of boron trifluoride as catalyst, a neutral product was obtained having epoxide content 0·198 equivalent/100 g. Attempts were made in the course of the year to replace dewaxed shellac with *bhatta* shellac but it made the reaction very slow. The acid value of the product was nil and epoxide value only 0·0458 equivalent/100 g. There was considerable difficulty in filtration also due to the presence of wax in shellac. It is thus evident that dewaxed lac is better than waxy lac for its epoxidation.

In another set of experiments, to a mixture of sodium shellaccate (100 g), epichlorohydrin (300 g) and benzyltrimethylammonium chloride (2 g) were added and the mixture refluxed for 30 min with stirring. It was cooled to 50°C and washed with warm water thrice. The acid value of the product was found to be nil and epoxide value 0·0476 equivalent/100 g. A 25 per cent solution of this product was prepared in xylene/butanol mixture (1:1) and films prepared on glass and tin plates. To a portion of the solution, a few drops of triethylenetetramine (TETA) were added and films prepared. Properties of the air dried and baked (at 150°C for 30 min) films were studied. Baked films obtained without TETA were hard, glossy and flexible but resistance to water, solvents and chemicals was poor whereas those containing TETA had all these properties and in addition were resistant to water, chemicals like mild alkalies and dil. acids, and solvents like acetone, ethanol, trichloroethylene, etc.

To simplify the reaction process further, shellac was dissolved in aqueous sodium hydroxide (equivalent to the acid value of shellac) making a 50 per cent solution and benzyltrimethylammonium chloride (1 per cent) was added. It was heated on a water bath at 90°C while epichlorohydrin was added dropwise with vigorous stirring. The reaction was carried out for 1 hr and the product separated out as a lump. After washing it thoroughly with hot water (50°C) and drying, the product when dissolved in ether was found to be partly soluble (30 per cent). The ether soluble portion was a soft and sticky mass with acid value nil and epoxide value 0·0977 equivalent/100 g. It cured hard when mixed with appropriate quantity of TETA.

The ether insoluble portion was a hard and tough material, soluble in dioxane and xylene/butanol mixture. The acid value of this product was nil and epoxide value 0·0287 equivalent/100 g. Films were prepared from a xylene/butanol solution with addition of a few drops of TETA. The baked films were quite hard, glossy and flexible and had good water resistance as well as resistance to solvents like acetone, spirit, etc.

(S. K. M. Tripathi and S. C. Sengupta)

(b) RESEARCHES ON HAND

1. Fundamental Studies

(a) *Macrocyclic molecules*

Aleuritic acid (9,10,16-trihydroxy palmitic acid), one of the major constituent acids of shellac, is an interesting raw material for the synthesis of

macrocyclic molecules of industrial importance. In connection with this synthesis, the following two intermediates were prepared from aleuritic acid.

(i) *Iso-aleuritic acid* (7,8,16-*trihydroxypalmitic acid*)

Methyl aleuritate (m.p. 68°-70°C) was acetonated with acetone in presence of conc. sulphuric acid and the ω-hydroxy group oxidized to carboxyl with potassium permanganate in acidified (acetic acid) acetone medium. The half ester thus obtained was reduced to iso-aleuritic acid (m.p. 90°-92°C) by the Bouveault-Blane method using sodium in ethanol. IR spectrum showed absorptions for C=O at 1720 and 1690 cm^{-1}.

p-Phenyl phenacyl ester of this acid and aleuritic acid were prepared, which melted at 124°-126° and 110°-111°C respectively.

(ii) *ω-bromo-9-hexadecenoic acid*

Aleuritic acid was dissolved with shaking in a solution of hydrogen bromide in glacial acetic acid (d, 1·3). Shaking was continued for 3 hr and the mass left overnight. The solution was poured in water and extracted exhaustively with ethyl acetate. The extract was washed and the solvent evaporated giving the tri-bromo derivative as a viscous light brown oil, which on debromination with Zn dust/alcohol yielded *ω*-bromo-9-hexadecenoic acid as viscous liquid.

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

(b) *Separation and study of components of lac resin*

It was mentioned in earlier reports that *palas* hard resin, on fractionation by urea-complex formation method, gave 3 fractions, namely, A, B and C. B on further fractionation by the same method gave 3 fractions, namely, B. 1, B. 2 and B. 3.

The 3 fractions from B gave positive test for aldehydic group with Tollen's reagent, indicating the presence of jalaric acid.

B. 1 (25 g) was hydrolysed with sodium hydroxide solution (112·5 ml, 1·75 N) at room temp. (20°-22°C) for 24 hr. The hydrolysed product was acidified with aqueous phosphoric acid (45 ml, 1:1) with mechanical stirring, the aqueous portion decanted off and the gummy mass repeatedly washed with water and filtered. The washings were extracted with ethyl acetate (125×2 ml), washed with water (60 ml), dried and solvent removed in vacuum. The water soluble product (12·2 g) was examined by TLC (solvent system, chloroform: methanol: acetic acid, 90:10:2) when jalaric acid was found to be the main acid along with other minor acids.

The gummy mass (12·5 g) left after the separation of water soluble acids was converted to methyl ester and an ether insoluble white compound (1·18 g) was obtained. This on crystallization melted at 69°C and was confirmed as methyl aleuritate by TLC.

The mixture of esters was examined by TLC which revealed the presence of aleuritate, shellolate and epishellolate besides other esters. The esters (6·8 g) were fractionated over silica-gel column eluting with different proportions of benzene and methanol and 7 fractions collected. None of these fractions was found to be pure.

Of these 7 fractions, B. 1·4 (0·42 g) was refractionated over silica-gel eluting it with different proportions of benzene and ethyl acetate and 4 fractions collected.

Of them, B. 1·4-1 appeared to be a mixture of aleuritate and shellolate and B. 1·4-2 (0·0492 g) and B. 1·4-3 (0·1228 g) to be a mixture of mid-hydroxy, ω-hydroxy and saturated esters. B. 1·4-2 was further fractionated over silica-gel impregnated with silver nitrate, but no pure fraction could be obtained. B. 2 (10 g) was also studied and by adopting the same procedure as mentioned above, water soluble (2·3 g) acids were removed. The gummy mass (7·5 g) was converted to methyl esters (7·85 g) and is at present under study.

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

(c) *Estimation and identification of shellac in presence of other resins*

There is hardly any suitable test for the identification and estimation of shellac specially when it is mixed with other resins in various formulations. In order to develop a quick method for identification of shellac, an approach was made to identify it through any of its functional groups giving some specific reaction. Shellac on alkaline hydrolysis yields jalaric acid which is one of the major constituent acids and has one aldehydic group, whereas under similar condition, no other resin yields a water soluble compound containing an aldehydic group. The alkaline shellac hydrolysate only responded to fuchsin sulphurous acid test and, based on this observation, a spot test was successfully developed. The other resins taken were rosin, damar, sandarac, benzoin, mastic, dragons blood, pontianac, kauri, copal, gamboge and plexigum. In an admixture up to 10 per cent of shellac, it can be very easily detected by the spot test. However, if the percentage of shellac is lower, the mother liquor after hydrolysis needs to be extracted with ether and the extract concentrated by boiling off the ether. Following this method, shellac present up to 3-4 per cent could be identified by the spot test developed.

(R. Prasad and S. C. Sengupta)

(d) *Depolymerization of polymerized shellac*

Attempts were made to optimize the hydrolytic process for depolymerization from all angles as well as to understand the mechanism of the degradation reaction.

First of all, the experiments were run making use of optimal amounts of polymer, acid and water. It was observed that the presence of additional water always led to a diminution in the degree of degradation.

The hydrolytic process was then optimized with respect to the reflux time by keeping the composition of the feed constant. It was observed that the extent of degradation was maximum only after 3 hr.

The degraded products, recovered from the hydrolysates by the addition of sodium chloride solution (1 per cent, three times of the volume of the hydrolysate), were subjected to IR spectral analysis. A comparison of the IR spectra of the degraded products of different degradation levels has offered a definite knowledge of the mechanistic patterns of the reaction. Further, the experiments were replicated with different amounts of acid. An improvized method of analysis was adopted to obtain the reproducible results in this direction for the earlier results seemed to be fortuitous. Besides, an attempt was made to examine the dependence of the degree of degradation of the polymerization level of the substrate. It was found that the lesser the degree of polymerization of the substrate, the greater the degree of degradation.

The effect of sodium chloride on the rate of degradation is under study.

An attempt is now being made to optimize the degradative process on the basis of these results.

(A. Kumar)

2. Modification of shellac

(a) *Ion exchange resin from shellac*

Cation exchange resin was prepared from sulphonated lac, resorcinol and *p*-formaldehyde. Sulphonated lac was prepared by carrying out the sulphonation of lac with sulphuric acid in alcoholic medium.

Sulphonated lac (22 g) was dissolved in sodium hydroxide (4 per cent) and was boiled. Thereafter *p*-formaldehyde (1·5 g) and resorcinol (11 g) were added after 1 hr and boiled together on a water bath. The whole mass was cooled down to 50°C and *p*-formaldehyde (1·5 g) was further added. Again *p*-formaldehyde in two lots (each of 1·5 g) was added when a black, hard resin resulted which was thoroughly washed with water, spirit and sodium hydroxide (10 per cent) to get a product with no colour throw. The resin was leached with hydrochloric acid (Analar, 10 per cent) and washed free from acid with distilled water. Some of the properties of the H-form resin were determined and are as follows:

Yield	50 per cent
Moisture	3 per cent
Sulphur	4·5 per cent
Mesh size (ASTM)	20-40

CATION EXCHANGE CAPACITY OF AMBERLITE AND ION EXCHANGE RESIN FROM LAC

Resin	In presence of NaCl at 25°C *p*H 7	From $BaSo_4$ determination	From limiting exchange with $BaCl_2$ soln
Amberlite IR-120	4·18	4·16	4·21
Ion exchange resin from shellac	9·94	9·90	9·92

The resin developed is completely insoluble in water, spirit or alkali. It can be safely used from *p*H 1-13, and remains unaffected when heated alone up to 170°C.

Stability of the ion exchange resin

Alcoholic or aqueous alkaline shellac hydrolysate (10 per cent) was passed through shellac ion exchange resin and cations exchanged up to 15 times and constants like acid and sap. values determined. After 15th time, acid value dropped from 201 to 164 and sap. value from 203 to 168. It was inferred that the resin can be used up to 15 times without any damage to the resin in its performance as an exchanger when used in a column. A control with Amberlite IR-120 was also run side by side.

(A. Rahman and P. R. Bhattacharya)

(b) *Modification of total hydrolysed lac*

(i) Investigations were carried out to study the modification of hydrolysed lac obtained from refuse lacs with phthalic anhydride. The end products obtained by modifying total hydrolysed lac with 25 to 30 per cent of phthalic anhydride gave the best performance when used in water thinnable paint formulations. When baked at 150°C for 20-30 min, smooth films with good flexibility and adhesion were obtained which were hard (scratch hardness, 1800 g) and water resistant (7 days). These paints could be stored for more than a year in air tight containers and no deterioration in their properties could be noticed till now.

(ii) *Comparison of total and conventional hydrolysed lacs*

It was reported earlier that total hydrolysed lac modified with linseed oil fatty acids could be used to prepare water thinnable paints having good adhesion, flexibility, hardness and water resistance. But when total hydrolysed lac was replaced by the conventional hydrolysed lac, gloss and flexibility of the paints deteriorated. The gloss and flexibility of films may be thus due to the presence of water soluble terpenic acids and, therefore, experiments were initiated to study their properties. The total hydrolysed lac was extracted to dryness to obtain the water soluble portion (the terpenics). It was a hard, brittle and pale yellow product with acid and saponification values 215 and 270 respectively. It had a very long polymerization time and even after 18 hr of heating at 150°C, its acid value was 134 and the hard product was soluble in alcohol. Its films from aqueous medium were glossy but hygroscopic and possessed poor water resistance.

(iii) *Water thinnable wash primer*

Investigations were also initiated to study the preparation of water thinnable wash primers from Rebulac modified with linseed oil fatty acids using zinc tetroxychromate as pigment. Air dried films obtained from it were flexible and had good adhesion, scratch hardness (1700 g) and water resistance (4 days). But these primers could not be stored for more than 3 months. However, the storage stability could be increased to 7-8 months by the addition of maleic anhydride (1-2 per cent). The films prepared thereof were hard (scratch hardness, 1500 g), flexible and water resistant (4 days). However, fine cracks developed after 6 months.

(R. K. Banerjee and S. C. Sengupta)

3. Use of shellac and modified shellac in surface coatings

(a) *Water thinned shellac emulsion paint for internal decoration*

It was reported earlier that the addition of sodium carboxymethylcellulose (0·2 per cent) in the emulsion paint sufficiently improved the viscosity and made the paint suitable for application by any conventional technique. Though on storage the paint was found to thin down, the performance remained the same. A close examination of the painted panel, however, showed some growth of fungus. This drawback was overcome by adding pentachlorophenol (0·5 per cent) in the above composition. The emulsion paint obtained after the above modifications produced hard, smooth and adherent films on various substrates and did not show any sign of deterioration up to 3 months so far.

The emulsion paint thus developed was prepared on semi-pilot scale (2 gallons) without any appreciable difficulty. Forty litres of this paint were thus prepared and applied on the interior walls of the staff club of ILRI by spraying.

Samples of this paint were also sent to two parties for their evaluation and comments.

Experiments were also carried out to study the suitability of double boiled linseed oil for this purpose. It was observed that the paint prepared from double boiled linseed oil also gave satisfactory performance and compared favourably with the above composition.

An application for a patent entitled "Shellac emulsion paint for wall finishes" with complete specification was submitted to the Patent Office, Calcutta.

(M. Mukherjee and S. Kumar)

(b) *Water based red oxide primers and their application by electrodeposition*

It was reported earlier that water thinnable shellac and modified shellac primers can satisfactorily be applied on mild steel surfaces by the latest technique of electrodeposition and that the films obtained from modified shellac primers showed overall good performance. The films obtained from plain shellac, however, did not show adequate corrosion resistance and therefore further experiments were made to improve the corrosion resistance of plain shellac primer film.

The usual methods for improving the corrosion resistance, i.e., by increasing the film thickness, incorporating anticorrosive pigments and their mixtures, etc. were tried.

Since the electrodeposited film becomes non-conductive after a certain time of deposition, this aspect of increasing the thickness was attempted by using conductive pigment, namely, graphite (10 per cent) in the plain shellac primer composition. The films obtained from this modified composition were comparatively thicker and also a second coat could be applied over them even after baking but unfortunately the adhesive properties were very poor. Deposition of the film was studied by altering the applied voltage, current density, *p*H, etc. but without success.

The other method for improving the corrosion resistance was then studied by incorporating anticorrosive pigment (red lead 10 per cent) in the primer composition. In this case, a non-uniform, porous and thick film was obtained. Even on prolonged deposition, the porosity of the film did not disappear and, as a result, the corrosion properties did not show any improvement.

Deposition of the film was studied by altering the various conditions, such as, applied voltage, current density, *p*H, etc. but no fruitful results could be obtained.

(A. Pandey and S. Kumar)

(c) *Use of lac for coating of insecticides and pesticides*

Microencapsulation is at present a rapidly expanding chemical process of micropackaging. This technology in the field of pesticides and insecticides has been applied to increase their specificity and persistance, and to reduce the repellency.

Shellac is an excellent film former and, therefore, its suitability as a coating material for insecticides and pesticides was tried in the present study. Aqueous phase separation method, i.e., coacervation or microencapsulation was tried with lac. Shellac hydrosol was prepared by dialysing 15 per cent w/v aqueous

ammonical solution of shellac (D.L.) against distilled water through a thin cellophane paper bag.

Gelatin was dissolved in water and same weight of shellac hydrosol added and the mixture emulsified in presence of an emulsifying agent. The whole mass was kept well agitated with the help of a mechanical stirrer. At this stage, pesticide or insecticide to be encapsulated was added. D.D.T. (75 per cent) and Biotrol® (*Bacillus thuringiensis* Berliner) in powder form were tried. After addition, the material to be coated was dispersed by vigorous stirring. Coacervation was induced by changing the *p*H of the system to about 4-4·5. The agitation was then discontinued and the system cooled.

Experiments were also carried out using only shellac hydrosol. The effect of addition of sodium alginate was also studied.

Materials, after and before inducing coacervation, were examined under microscope. It was observed that more or less continuous wall had formed around the insecticide particles.

Further, for a study on spores viability of Biotrol®, bacteriological plating technique was adopted. It was observed that the process had no adverse effect on spores viability.

(B. C. Srivastava, J. N. Chatterjea and S. Kumar)

(d) *Water thinned paints for internal decoration*

It was reported that water soluble linseed oil obtained both by reacting linseed oil with maleic anhydride and citric acid when mixed with aqueous lac solution produces a varnish which serves satisfactorily as a vehicle for water thinned decorative paints.

Further samples of water thinnable paints were prepared and applied on the flower pots (cemented) for evaluation. Hard, smooth and nontacky finish was obtained. Drying characteristics of the paint were also good. A patent application with complete specifications was submitted to the Patent Office, Calcutta.

(A. K. Dasgupta and S. Kumar)

4. Decorative laminates

Decorative laminates of the type Sunmica® and Formica® are commonly used as table tops and for furnishing of shops, etc. In these laminates, amino resins are used as binder for the top layer. Recent studies on the modification of lac with amino resins have shown that lac amino resin varnishes also possess appreciable improved heat and water resistance and excellent adhesion. The present study was, therefore, taken up with a view to assessing the suitability of lac melamine resin varnishes as binder for the top layer of the decorative laminates.

Different types of papers especially absorbant, craft paper, α-cellulose paper, etc. were impregnated in the lac melamine resin varnish, dried in the air and thereafter in the oven to the desired degree. These coated paper sheets were piled together, cut to size and pressed in the electric press at 120°C for 30-40 min under a pressure of 1200 lbs p.s.i. The laminates so obtained were quite smooth

and hard. These were then tested for various properties, such as, scratch proofness, water resistance, boiling water resistance for 2 min and it was found that the panels stood the tests satisfactorily.

(A. K. Dasgupta, S. Kumar and J. N. Chatterjea)

5. Studies on rocket fuel

It was reported that when shellac is modified and hot mixed with oxidizers, accelerators and catalysts and cured in a mould, it forms a compact fuel which burns uniformly and leaves no ash. Further experiments have shown that shellac, like synthetics, can also be cold blended with oxidizers and other ingredients to get into the form of a putty. This putty when cured in the mould formed a compact fuel with good mechanical properties especially hardness. These propellants when subjected to burning tests burnt smoothly and vigorously and left no ash. The flame length and the burning rates were 12-14″ and 0·04″ per second respectively.

After systematic burning rate studies, the propellants were charged in a rocket motor for static firing. It was observed that when a small nozzle was used, the fuel burnt instantaneously but when an appropriate nozzle was used, the fuel burnt smoothly throughout the experiment.

After the adjustment of nozzle size and successful static firing a 150 g charge was loaded in the rocket motor for determining the thrust as well as the specific impulse. During entire experiment, the fuel burnt steadily and smoothly and gave a constant pressure which was noted by the continuity of the flame. A thrust of 16 kg was recorded in the graph.

(S. Kumar, A. K. Dasgupta and J. N. Chatterjea)

(c) RESEARCHES CONTEMPLATED

(1) Study on lac wax
(2) Modification of shellac with ethylene/propylene oxide
(3) Creating unsaturation in aleuritic acid and its addition polymerization

D. TECHNOLOGY DIVISION

(a) RESEARCHES COMPLETED

1. Improvement in the processing techniques

Modification of lac wax

Lac wax, specially the one recovered from wash water, is generally soft and normally all types of lac wax contain this soft fraction. Earlier, this soft fraction was separated by fractional precipitation with the help of either acetone or *n*-hexane. As the use of an organic solvent is costly and requires special equipments, some other alternative process was searched for, preferably in the aqueous medium.

It was found that if this wax is treated with alkali (caustic potash or soda), a fraction saponifies easily and remains in suspension in water while the other separates as a solid mass and floats at the top. The latter part is much harder

and possesses better qualities than the former. Details of this treatment were, therefore, worked out. The optimum conditions found were as follows:

Crude lac wax is boiled with 2 per cent of its weight of sodium hydroxide in water as a 0·2 per cent solution for 4 to 6 hr. On cooling, the hard fraction solidifies and floats on the top, which is taken out and washed. The portion which remains as emulsion in water may be recovered by treating it with dilute sulphuric acid. Several experiments taking 500 g of crude wax were carried out and the process was found to work satisfactorily. The analytical results of a typical sample are given in Table 19.

TABLE 19 — PROPERTIES OF LAC WAX AND ITS FRACTIONS

Type of wax	Yield %	Solvent retentivity power	Penetration value
Crude	—	33	3·5
Hard	88	46	2·5
Soft	12	27	4·8

The results show that the properties of the hard fraction are better than those of the original wax. The hard as well as the soft wax could be bleached according to the methods standardized earlier.

(A. K. Ghosh)

2. Pilot plant studies on the manufacture of lac dye

Pure lac dye was prepared in several lots taking 5 kg of calcium salt of dye per charge. The dye obtained had all the qualities similar to the dye prepared earlier.

(A. K. Ghosh)

(b) RESEARCHES ON HAND

1. Improvement in the processing techniques

(a) *Dewaxing of lac (in solvent other than spirit)*

Study to use iso-propyl alcohol as an alternate solvent in place of spirit (which is in short supply) for dewaxing lac was started during the course of the year.

Ten per cent solution of seedlac was prepared in (i) methylated spirit, (ii) alcohol and (iii) iso-propyl alcohol of same strength (90 per cent). The solutions were filtered in the cold (below 10°C) and the dewaxed lac reclaimed by precipitating with sodium chloride solution (1 per cent). The products were washed free of salts and then boiled with water to remove residual solvent, dried and powdered.

The properties of the dewaxed lacs thus obtained are presented in Table 20 from which it will be seen that the product obtained by precipitation from iso-propyl alcohol has the lightest colour but lowest yield. Life and flow are of the ame order.

TABLE 20 — PROPERTIES OF DEWAXED LAC OBTAINED FROM DIFFERENT SOLVENTS

Sl. No.	Properties	Original seed lac	Solvent used		
			Methylated spirit	Alcohol	Iso-propyl alcohol
1	Yield, %	—	76·0	85·0	70·0
2	Life (min)	60·0	30·0	30·0	30·0
3	Flow (mm)	100·0	100·0	90·0	95·0
4	Colour	10·0	10·0	10·0	8·0
5	Acid value	69·7	57·0	59·9	54·0

Attempts to increase the yield of dewaxed lac obtained by using iso-propyl alcohol are in progress.

(B. P. Banerjee and B. B. Khanna)

(b) *Bleaching of lac with chlorine-free bleaching agents*

Pilot plant trial of new technique developed

It was reported last year that lac can be bleached while in suspension during a period of only 4 hr by using combined process of bleaching with sodium hypochlorite and hydrogen peroxide as against 24 hr taken by the conventional process. The product obtained has, apart from good colour, very good life under heat and flow.

The process developed was examined on semi-pilot scale with 5 and 10 kg of seedlac. It was observed that there is brisk frothing at the time of addition of hydrogen peroxide which necessitates use of larger vessels as otherwise the solution has a tendency to overflow. Also efficient and continuous stirring is required at the time of addition of hydrogen peroxide.

The bleached lac obtained had all the good properties noticed with smaller lots.

(L. C. Mishra and B. B. Khanna)

2. Rubber-shellac combinations

(i) Last year, the effect of incorporation of modified lacs into natural rubber was studied. The study was extended to styrene-butadiene rubber (SBR) during the course of this year.

Rosin lac ester obtained by reacting 25 g of lac with 50 g of rosin (1 : 6·6 molecular proportion) at a temp. of 260 ± 5°C for 35 min, having an acid value 93·0 and hydroxyl value 86·3, was taken for this purpose. It was found that the ester acts as a processing aid and also raises tensile strength, tear resistance and hardness of styrene-butadiene rubber (Table 21).

(ii) In order to substitute coumarone-indene resin, which is imported for use in rubber compositions, a comparison of its performance with that of shellac was made. The study has shown that shellac behaves better than coumarone-indene resin in effecting the mechanical properties such as modulus, tensile strength, tear resistance and hardness in gum stock of SBR (without filler), when either MBT

TABLE 21 — EFFECT OF INCORPORATION OF ROSIN LAC ESTER ON THE PROPERTIES OF SBR

[Base mix composition: SBR (1502), 100; zinc oxide, 4; sulphur, 2; stearic acid, 1; accelerator 1·5 and PBN, 1 part]

Rosin lac ester added (parts/100 parts SBR)	Optimum cure time at 140°C min.	Mooney viscosity (ML_{1+4}) at 120°C	Scorch time min-sec	Modulus at 200% elongation (kg/cm²)	Ultimate elongation (%)	Tensile strength (kg/cm²)	Tear resistance (kg/cm)	Durometer hardness Shore A	Impact resilience (%)
				ACCELERATOR MBT					
0	45	50·0	44-26	9·5	250	11·9	12·5	46·0	70·2
5	45	40·0	38-35	7·1	500	14·1	16·1	44·5	63·25
10	45	37·0	36-44	7·2	550	18·6	21·0	45·0	60·1
15	45	33·0	34-15	—	450	22·2	22·2	49·0	62·4
20	45	30·0	31-31	7·4	500	23·0	22·5	50·0	62·1
				ACCELERATOR CBS					
0	30	40·0	42-20	11·5	250	12·4	11·8	50·0	77·8
5	30	35·5	40-25	9·9	500	19·3	—	48·0	71·6
10	30	33·5	39-27	9·6	400	17·3	18·8	49·0	68·8
15	30	30·0	35-25	8·5	850	28·9	26·4	49·0	61·7
20	30	27·0	30-31	9·8	630	29·9	31·4	49·0	63·5

or CBS is used as the accelerator. Using china clay as the filler, shellac gives better hardness and tear resistance while coumarone-indene resin gives better tensile strength and modulus.

As regards swelling behaviour of these compositions in benzene and petroleum ether (b.p. 60°-80°C), it was found that shellac behaves better than coumarone-indene resin both in gum stock (i.e. without filler) and using china clay as the filler, when MBT is used as the accelerator (Table 22).

(R. Singh and B. B. Khanna)

(c) RESEARCHES CONTEMPLATED

(1) Manufacture of shellac and dewaxed lac in aqueous medium
(2) Correlation of the properties of shellac in relation to seedlac
(3) Manufacture of sealing wax white variety and by cold setting or continuous process
(4) Correlation of bleach index of lac with its colour

TABLE 22 — COMPARISON OF THE PERFORMANCE OF SHELLAC AND COUMARONE-INDENE RESIN

[Base mix composition: SBR (1502), 100; zinc oxide, 4; sulphur, 2; stearic acid, 1; phenyl-β-naphthylamine, 1; accelerator, 2 parts]

Shellac or coumarone-indene resin (parts/100 parts rubber)	Optimum cure time at 140°C (min.)	Mooney viscosity (ML_{1+4}) at 120°C	Scorch time (min-sec)	Modulus at 200% elongation (kg/cm²)	Ultimate elongation (%)	Tensile strength (kg/cm²)	Tear resistance (kg/cm)	Durometer hardness Shore A	Impact resilience (%)	Effect of solvents (wt increase %)	
										Benzene	Petroleum ether
				RESIN SHELLAC: ACCELERATOR MBT							
0	40	50·0	44-26·0	10·1	320	12·1	11·3	46	72·3	362·0	81·3
5	30	41·5	30-58·5	12·8	330	16·8	14·7	48	68·8	343·0	96·2
10	30	—	—	—	450	26·7	20·5	47	58·4	380·0	81·1
				RESIN COUMARONE-INDENE: ACCELERATOR MBT							
5	30	43·0	44-11·0	6·7	420	10·4	9·6	35	44·3	547·0	109·6
10	20	—	—	7·4	510	13·6	11·2	37	50·1	488·0	93·6
				RESIN SHELLAC: ACCELERATOR CBS							
0	20	54·0	47-25·0	12·2	300	13·3	11·7	43	58·4	309·0	71·2
5	40	40·0	20-07·0	12·3	300	15·7	19·8	46	56·6	333·0	78·5
10	30	—	—	14·9	380	22·3	16·8	48	55·1	348·0	77·7
				RESIN COUMARONE-INDENE: ACCELERATOR CBS							
5	20	39·0	35-04·5	12·1	320	16·4	11·5	41	71·6	315·6	75·2
10	40	—	—	11·2	350	16·1	15·5	45	65·2	346·6	71·5
				RESIN SHELLAC: FILLER CLAY (100 PARTS): ACCELERATOR MBT							
0	30	—	—	18·2	850	89·7	35·5	60	48·2	183·8	40·8
5	40	54·0	21-12·0	21·1	840	62·2	42·1	65	42·8	207·6	45·7
10	40	—	—	18·8	640	41·3	35·6	64	41·4	224·2	42·3
				RESIN COUMARONE-INDENE: FILLER CLAY (100 PARTS): ACCELERATOR MBT							
5	40	55·5	26-19·5	22·7	780	90·4	36·8	58	47·2	220·6	43·4
10	40	—	—	22·2	810	72·8	37·3	56	42·8	225·9	42·7

3. EXTENSION

(A) ENTOMOLOGY DIVISION

As already indicated in the previous reports, all activities relating to extension of lac cultivation are the responsibilities of the Directorate of Lac Development under the Ministry of Food and Agriculture, Government of India, the functions 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 the data of larval emergence during the different seasons on the basis of examination of samples received from different lac-growing areas. 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) ".

Large scale lac cultivation on *palas* at Kundri

Technical help continued to be rendered to the Bihar Forest Department for lac production in Kundri lac orchard having a total of about 40,000 *palas* trees. Of these, about 27,000 *palas* trees remained under lac operations during the year producing about 1307 kg of sticklac. The broodlac produced in the area (about 1631 kg) was used to inoculate 6553 trees to raise the following *baisakhi* 1973-74-cum-*katki* 1974 crop which has progressed satisfactorily till the end of the period under report.

Namkum plantation

General upkeep of the plantation was maintained as far as possible. Seedlings of various lac-hosts were raised in nursery beds for filling up the gaps and vacant plots and for use in pots for laboratory experiments.

Training in lac cultivation

Six in-service candidates, four from Uttar Pradesh and two from Bihar successfully completed the 6-month course in " Improved Methods of Lac Cultivation " during the session April to September.

Four candidates, three from the Forest Department, Bihar and one private joined the followi. g October 1973 to March 1974 session.

(B) EXTENSION DIVISION

Extension activities regarding processing and utilization aspects of lac are the complete responsibility of this Institute as far as industries in India are concerned. For this purpose, the Institute at present maintains an Extension Division, the main activities of which are technical service and development work, publicity and propaganda, production and sale of special lacs and lac products, testing and training.

(a) Technical service and development work

(1) Technical service was as usual provided to all those interested. A number of enquiries were received regarding lac wax, lac dye, lac-based adhesives, dry mounting tissue paper, melfolac, dewaxing of lac, bleached lac, spiritless French polish and sealing wax. These were attended to and technical information supplied. In addition, samples of melfolac, gasket shellac compound, shellac emulsion paint, lac wax and lac dye were supplied to various industries for testing their suitability. A few of the more important of these are listed below:

(i) A request was received from one private industry for a cold setting type shellac based cement for joining the metal to metal flange joints in the rotary oil sealed vacuum pumps manufactured by them, which could stand temperature up to 85°-90°C and vapour pressure 0·01 Torr. Four samples were prepared and sent for testing the suitability. The results are awaited.

(ii) A sample of dye known as Tana-colour® was received from Japan for comparative studies vis-a-vis lac dye. Lac dye was found comparable with this dye in respect of the chemical properties mentioned.

(iii) A leading manufacturer was supplied with the technology for the bonding of grits of emery on wheels.

(iv) A sample of lac dye has been sent to a leading Milkfood manufacturer for trials in their powdered food products.

(2) A few schemes on processing of lac and utilization received from different parties for scrutiny and advice were attended to. A scheme for the manufacture of micanite was prepared for the Cottage and Small Scale Industries Deptt., Govt. of West Bengal, which has since been reported to have been included in their Fifth Five Year Plan.

(b) Publicity and propaganda

The Institute supplied lac exhibits to the interested parties for display in different exhibitions.

A meeting with the press representatives was arranged on 9th January in order to acquaint them with the latest activities of the Institute with a visit to the experimental area to show the success achieved in the control of lac predators. The press highlighted the achievements in the leading newspapers.

The Institute participated in a Lac Growers' Meet organized by the Directorate of Cottage and Small Scale Industries, Govt. of West Bengal at Jhalda (Purulia) on 20th February. The Scientists delivered lectures to the farmers on various aspects of improved lac cultivation.

(c) Production unit

The production unit continued to function. Five grades of special shellacs, viz. two grades of bleached lac — refined and regular, two grades of water soluble lac and one grade (ASK) of autoclave shellac, as well as hydrolysed lac, *kiri* lac and lac wax were manufactured and sold.

The total sale amounted to Rs. 22,765.44 as detailed below:

Material	*Quantity* (kg.)	*Value* (Rs.)
BRF grade bleached lac	120.00	1860.00
BR grade bleached lac	—	—
DXO grade water soluble lac	234.40	4579.25
DXG grade water soluble lac	59.50	906.50
ASK grade shellac	760.95	10,725.19
BHL grade bleached hydrolysed lac	90.00	2610.00
BOL grade hydrolysed lac	2.00	44.00
Kiri lac	193.00	296.50
Lac wax	35.00	560.00
Misc. lac products	—	1184.00
	Total	22,765.44

(d) Testing laboratory

Seventy-two samples were received for testing from lac manufacturers, Government organizations, etc., and in all 180 tests were carried out.

(e) Training

A technician deputed by a lac manufacturer was imparted a short term training in the processing and analysis of lac and lac products.

4. PAPERS PUBLISHED

Publication and Patents

Publications

The Institute publishes its research findings in leading Scientific and Technical journals. In addition, a few books and one monograph have also been published.

The total number of publications as on 31st December, 1973 is as below:

1. Bulletins	
(i) Chemical	131
(ii) Entomological	61
2. Technical notes	30
3. Research notes	
(i) Chemical	85
(ii) Entomological	52
4. Miscellaneous technical publications	
(i) Physico-chemical	25
(ii) Entomological	48
5. Books and Monographs	14
6. Pamphlets and leaflets	24

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

List of Papers Published during the Year 1973

Sl. No.	Authors	Title of paper	Name of journal
		A. ENTOMOLOGY DIVISION	
1.	Chauhan, N. S.	Cytogenetic analysis of a unique genetic system in the lac insect.	*Proc. Second General Congr.* of SABRAO. Indian Agric. Res. Inst., New Delhi: 51-52 (*Abstr.*).
2.	Chauhan, N. S. and Teotia, T. P. S.	Note on a newly discovered lac insect producing white lac.	*Indian J. agric. Sci.* **43**: 1086-1087.
3.	Chauhan, N. S. and Teotia, T. P. S.	A new variant in the lac insect, *Kerria lacca* (Kerr).	*Entomologists' Newsletter* 3(5): 33-34.
4.	Chowdhury, M. K.	Large scale rearing technique of *Brachymeria tachardiae* Cam. (Chalcidoidae: Hymnoptera), a pupal parasite of *Holcocera pulverea* Meyr. (Blastobasidae) and *Eublemma amabilis* Moore (Noctuidae), the predators	*Sci. & Cult.* **39**(7): 311-312.

		of lac insect *Kerria lacca* Kerr.	
5.	Gokulpure, R. S.	Record of three Agromyzids from Central India.	*Sci. & Cult.* **39**(4): 193-194.
6.	Gokulpure, R. S.	Observations on the biology of *Terias blanda silhetana* Wall (Lepidoptera: Pieridae), a serious pest of *Cassea tora* Linn.	*Indian Agric.* **16**(3): 221-226.
7.	Gokulpure, R. S.	New records of hymenopterous parasites of pea leaf miner, *Phytomyza atricornis* Meigen (Diptera: Agromyzidae)	*J. Bombay nat. Hist. Soc.* **70**(1): 223-224.
8.	Malhotra, C. P.	Enemies of the lac insect, *Kerria lacca* (Kerr) and their control.	*Proc. Symposium on Oriental Entomology*. Deptt. of Zoology, Univ. of Calcutta: 93 (*Abstr.*).
9.	Malhotra, C. P. and Mishra, R. C.	Discriminate oviposition by the lac predator, *Eublemma amabilis* Moore, and possibilities of suppressing its population by trap cropping.	*Proc. 60th Indian Sci. Congr.* Part III. Abstract. p. 675.
10.	Mehra, B. P.	Distribution of the family Tachardiidae Cockerell 1901 with special reference to *Kerria lacca* (Kerr) in India and *Kerria chinensis* (Mahdihassan) in Thailand.	*Proc. Symposium on Oriental Entomology*. Deptt. of Zoology, Univ. of Calcutta: (Abstr.).

B. AGRONOMY AND PLANT GENETICS DIVISION

1.	Purkayastha, B. K. and Kumar, P.	Rooting of cuttings of *Albizzia lucida* Benth. as influenced by mixtures of growth promoting hormones.	*Ind. For.* **99**(2): 116-118.

C. CHEMISTRY DIVISION

1.	Kumar, S.	Single pack acid catalysed wood lacquer.	*Ind. Finish and Surf. Coatings* **25**(298): 8.
2.	Kumar, S.	A new viscometer for determining the shelf life of convertible coatings.	*Paintindia* **23**(4): 20.
3.	Kumar, S.	Lacquered tins for packaging and storage of shellac varnishes.	*Paintindia* **23**(5): 33.

D. TECHNOLOGY DIVISION

1.	Singh, R. and Khanna, B. B.	Lac and modified lacs as compounding ingredients of natural rubber, Part II — Epoxy resin modified lac and magnesium salt of lac.	*Res. & Ind.* **18**: 15-16.
2.	Banerjee, B. P. and Khanna, B. B.	Dewaxing of lac in aqueous medium.	*Res. & Ind.* **18**: 144-146.
3.	Ghosh, A. K. and Khanna, B. B.	Recent advances in the technology of lac processing and utilization of by-products of lac industry.	*Res & Ind.* **18**: 42-43.

5. CONFERENCES AND SYMPOSIA

A two-day seminar on 'Lac Production' held on 9th and 10th November, 1973 was inaugurated by Dr T. R. Mehta, Deputy Director General, I.C.A.R. with Professor S. C. Mandal, Vice Chancellor, Rajendra Agricultural University, Bihar as the Chief Guest. The programme included presentation of papers and discussion on various aspects of lac production, processing and utilization and organizing an exhibition to highlight the research achievements of the Institute. The seminar was attended by a large number of scientists, field officers and representatives of the industry. The papers presented in the Seminar are listed below:

(A) MANAGEMENT OF LAC-HOSTS

(1) P. Kumar and S. S. N. Sinha — Cytotaxonomy of lac-hosts.
(2) P. Kumar and Sohan Lall — Possibility of interspecific crosses in *Moghania* spp.
(3) Sohan Lall and P. Kumar — Occurrence and utility of *Rhizobium* species in the root nodules of lac-host plants.
(4) P. Kumar and B. K. Purkayastha — Vegetative propagation of lac-host plants with growth regulators.

(B) LAC CULTURE AND EXTENSION — RETROSPECT AND PROSPECT

(1) A. Bhattacharya, J. M. Dasgupta and R. C. Maurya — Improved techniques of kusmi lac cultivation.
(2) C. P. Malhotra — Package of practices for lac cultivation on *palas* (*Butea monosperma*) in hot climate.
(3) A. H. Naqvi and B. K. Purkayastha — Package of practices for lac cultivation on ber (*Ziziphus mauritiana* Lamk) in moderate climate.
(4) R. C. Maurya & A. Bhattacharya — Possibilities of utilising *Moghania macrophylla* for kusmi summer crop.
(5) B. K. Purkayastha — Possibility of kusmi lac cultivation on mixed plantation of *Moghania macrophylla* and *Albizzia lucida*.
(6) B. K. Purkayastha — Prospects of lac cultivation on plantation basis on bushy hosts.
(7) T. Bhowmik and R. C. Mohanty — Cultivation of lac on plantation basis.
(8) M. L. Bhagat and B. K. Purkayastha — Use of certain plants as brood preservers in lac culture — a review.
(9) R. S. Gokulpure, B. P. Mehra and J. M. Dasgupta — Propagation of lac on hosts of regional importance.
(10) R. C. Mishra, Sohan Lall and T. P. S. Teotia — Mechanisation of lac cultivation — Possibilities and prospects.
(11) Sohan Lall — Lac production in India — retrospect and prospect.
(12) R. C. Mohanty — A decade of lac production — retrospect and prospect.
(13) J. Singh — Lac extension in Bihar — package approach.
(14) J. Singh — Management of brood lac farms.
(15) J. Singh — Plantations of lac-host trees — its desirability and technique.

(C) ADVANCES IN LAC ENTOMOLOGY

(1) R. K. Varshney — Revision of the classification and taxonomy of the Indian lac insects.
(2) S. K. Jaipuriar and G. P. Tulsyan — Present state of our knowledge of cytology of lac insect.
(3) N. S. Chauhan — A unique genetic system in the lac insect *Kerria lacca* (Kerr.)
(4) Y. D. Mishra and N. S. Chauhan — Genetic variation in lac insects — a survey.
(5) B. P. Mehra — Environmental influence on the lac insect and lac culture. Part I — Influence of Abiotic or Physiographical Factors.
(6) B. P. Mehra — Environmental influence on the lac insect and lac culture. Part II — Influence of Biotic or Biocoenotic Factors and Superorganic Factors.
(7) B. Lal, B. P. Mehra and T. P. S. Teotia — Use of Biometer in lac ecology.
(8) D. C. Srivastava, B. P. Mehra and T. P. S. Teotia — Population studies on inimical and beneficial insects of lac.
(9) P. Sen and A. Bhattacharya — On the relative incidence of predators *Eublemma amabilis* Moore and *Holcocera pulverea* Meyr. on lac crops raised on tree and bushy hosts — vis-a-vis the relative incidence of the major beneficial parasites.
(10) N. Majumdar — Role of *Coccophagus tschirchii* Mahd. (Hymenoptera: Aphelinidae) in lac culture.
(11) P. Sen and A. Bhattacharya — Role of beneficial insects in the control of lac predators.
(12) C. P. Malhotra — Integrated control of enemies of lac insect, *Kerria lacca* (Kerr.) — philosophy and feasibility.
(13) R. C. Mishra, C. P. Malhotra and T. P. S. Teotia — Role of insecticides in controlling pests of lac.
(14) S. G. Chowdhury and C. P. Malhotra — Microbial control of the lac predators, *Eublemma amabilis* Moore and *Holcocera pulverea* Meyr.
(15) N. Majumdar and T. P. S. Teotia — Feasibility of controlling lac insect predators through the use of chemosterilants.
(16) S. G. Choudhury, T. P. S. Teotia and C. P. Malhotra — Possibility of controlling lac predators by antifeedants.
(17) R. C. Mishra, C. P. Malhotra and P. Sen — Preventive methods for the control of lac pests.
(18) C. P. Malhotra, R. C. Mishra and T. P. S. Teotia — Integrated control of enemies of lac insect *Kerria lacca* Kerr. — a reality.
(19) M. K. Chowdhury and A. Bhattacharya — Survival of lac insects on different hosts.
(20) A. H. Naqvi, R. S. Gokulpure and T. P. S. Teotia — Rearing of lac insect on artificial diet.
(21) A. H. Naqvi, A. K. Sen and T. P. S. Teotia — Artificial rearing of lac predators, *Eublemma amabilis* Moore and *Holococera pulverea* Meyr.
(22) R. S. Gokulpure, A. K. Sen and T. P. S. Teotia — Behavioral studies on the major lepidopterous predators of lac insect.
(23) A. K. Sen — Some biochemical and physiological studies on the lac insect predators, *Eublemma amabilis* Moore and *Holcocera pulverea* Meyr.
(24) R. S. Gokulpure — Hydrogen-ion-concentration and amino acid contents of *Hypena iconicalis* Walker, a serious defoliator of *Moghania macrophylla* (Willd.) O. Ktze.

(25) Jawahir Lal and N. S. Chauhan — Handling of lac insects in laboratory experimentaion.
(26) S. G. Choudhury — Studies on Limacodid pests of lac-hosts.
(27) B. N. Sah and B. P. Mehra — Lepidopterous pests of *Moghania macrophylla* and chemical control of important ones.
(28) R. S. Gokulpure and B. P. Mehra — Insects visiting lac insect for honey dew.

(D) STANDARDIZATION, MARKETING AND TRADE OF LAC

(1) R. C. Mohanty — Marketing of sticklac and price fluctuations.
(2) Ramesh Prasad and S. C. Sengupta — Standardization of the method for adhesion test of shellac to mica.
(3) C. L. Sharma — On the problem of marketing under shellac industry.

(E) LAC REFINING AND UTILIZATION OF BY-PRODUCTS

(1) L. C. Mishra and B. B. Khanna — Bleaching of lac — an improved technique.
(2) B. P. Banerjee and B. B. Khanna — Dewaxing of lac in aqueous medium.
(3) A. K. Ghosh — Advances in lac technology and recovery of by-products.
(4) R. K. Banerjee, A. K. Ghosh and S. C. Sengupta — Utilization of by-products of lac industry.
(5) B. Pathak and Asis K. Deb Roy — Probable utilization of lac dye.

(F) UTILIZATION OF LAC IN SURFACE COATINGS, ADHESIVES, FINE CHEMICALS, ETC.

(1) M. Mukherjee and Shravan Kumar — Shellac emulsion paints for wall finishes.
(2) A. K. Dasgupta, Shravan Kumar and J. N. Chatterjea — Water thinned paints for internal decoration.
(3) R. N. Majee and Shravan Kumar — Shellac paints.
(4) S. K. M. Tripathi, Y. Sankaranarayanan and S. C. Sengupta — Water based coatings from epoxy modified shellac.
(5) M. Islam, Niranjan Prasad and P. K. Ghosh — Shellac as adhesive.
(6) H. H. Mathur and S. C. Bhattacharyya — Synthesis of macrocyclic musks from Aleuritic acid.
(7) B. C. Srivastava and T. Bhowmik — Slow release lac coated urea fertilizer.

(G) SHELLAC IN JUTE, LEATHER, RUBBER, ELECTRICAL AND PLASTIC INDUSTRY

(1) S. R. Sengupta — Potential scope for the development of jute-shellac composite products.
(2) V. V. Subramanium and B. Lokanadam — Shellac in leather industry.
(3) R. Singh and B. B. Khanna — Use of shellac in rubber industry.
(4) M. Sanaulla and R. C. Mishra — Shellac in heavy electrical industries.
(5) H. P. Singh and B. C. Mitra — Shellac as a raw material in plastic industry.

(H) REVIEW AND CHEMISTRY OF LAC

(1) Niranjan Prasad, S. C. Sengupta and J. N. Chatterjea — Recent advances in the Chemistry of lac resin.
(2) M. Islam and T. Bhowmik — Improvement in life and flow of shellac.
(3) A. Rahman and P. R. Bhattacharya — Studies on the behaviour of concentrated sulphuric acid treated lac.
(4) A. Rahman and P. R. Bhattacharya — Anomalous behaviour of specific heat of bleached lac.
(5) R. Singh and P. R. Bhattacharya — Solvent release of the shellac varnish.
(6) P. C. Gupta and P. R. Bhattacharya — Kinetics of self-esterification of some Aleuritic acid derivatives.

6. SUMMARY

A. ENTOMOLOGY DIVISION

(a) RESEARCHES COMPLETED — Nil

(b) RESEARCHES ON HAND

1 (a). In an attempt to evolve an optimal cultivation schedule for *kusmi* lac production on *bhalia*, seven schedules were tried by varying the brood rate, lac operations and fertilizer application. Complete data on their comparative performance will be available next year.

(b) Three lac cultivation practices remained under field trial for utilizing *kusum* as host plant. The new two-coupe system involving self-inoculation did not perform better than the standard four-coupe system evolved earlier.

(c) *Bara salpan* was tried as an alternate host for the *kusmi* strain of lac insects while *rain tree* and *putri* for the *rangeeni* strain. Their performance has been poor.

(d) Ten plant species remained under study for their relative performance as host for the *rangeeni* and *kusmi* strains of lac insect. No definite trend was discernible in the studies made so far.

2 (a). An amino acid analysis of the *rangeeni* and *kusmi* strains of lac insect showed that while eight amino acids are common to both, a few are strain, season and age specific.

(b) For artificial rearing of lac insects, the newly emerged lac larvae were inoculated on solidified agar-agar soaked in synthetic diets. These, however, survived only for a maximum period of one week.

(c) To ensure regular supply of the lac predators for laboratory experiments, attempts were made to rear *E. amabilis* and *H. pulverea* on four artificial diets. Although in some diets partial success was achieved with the third instar larvae, the newly hatched larva failed to survive longer than 24 hr.

(d) The lac insects were reared on *palas*, *bhalia*, *ber* and *kusum* during the rainy generation. Their microorganisms were isolated and pure cultures maintained for further studies.

(e) The mating behaviour of *E. amabilis* and *H. pulverea* was studied. The presence of sex-attractants was confirmed in the female of both the predators.

3 (a). With a view to obtaining the superior *kusmi* insect having the *rangeeni* cycles for its propagation on *palas*, the strain crosses provided a few *kusmi* type insects which reproduced at the *rangeeni* time during the rainy generation last year. Their progenies, however, failed to survive during the summer months.

The lac insects from Madurai (Tamil Nadu) also reproduced at the *rangeeni* time during the rainy season generation. Since their progeny completed two life cycles in 13 months these are not expected to establish definite crop periods for successful propagation on *palas*.

(b) Study of crosses showed that the difference in the growth rate of *rangeeni* and *kusmi* strains is genetic and the *rangeeni* phenotype is dominant over the *kusmi*. A white lac insect was first discovered in a F_4 progeny and was found occurring in extremely low frequencies in a few wild stocks maintained at the institute, suggesting that it could be a recessive mutant with a selective disadvantage in its natural environment.

4 (a). The effect of photoperiod on lac insects was studied. It was found to have no effect on the growth and development of lac Insects.

(b) The effect of temperature on the development of lac insects was studied. The rate of development was faster at 30°C than at 27·5°C.

(c) A study was undertaken to determine the relative seasonal abundance of the inimical and beneficial insects of the lac insect to provide basic information required for the control of the inimical insects. Those dominated were *T. purpureus* and *T. tachardiae* among the inimical parasites; *E. amabilis* and *H. pulverea* among the lac predators and *B. greeni* and *A. tachardiae* among the beneficial parasites.

(d) The incidence of the lac predators under varying host densities of lac insect settlement was studied. No definite trend was discernible in the studies carried out so far.

5. Routine investigations were continued at the Regional Field Research Station, Dharamjaigarh to supplement lac production in the region with the locally available and introduced host plant species.

6 (a). Field trials of an integrated control schedule evolved earlier to control the lac pests showed that the use of synthetic net broodlac containers for crop inoculation and spraying the crop with 0·05 per cent Thiodan® and 0·05 per cent *B. thuringiensis* at appropriate times resulted in better suppression of predators' population and substantial increase in the yields of broodlac and sticklac in the treated plot than in the control.

(b) The distribution of the heavily inoculated (trap crop) and the lightly inoculated (main crop) trees was studied in various spatial arrangements. The incidence of *E. amabilis* was lowest and the crop yield highest when the trap crop was raised as a border for the main crop.

(c) The *baisakhi* 1973-74 crops were raised with broodlacs maturing at different times to study the effect of varying the time of crop inoculation on the incidence of lac pests. These crops are in progress.

(d) Exposure to sun with a temperature of 40°-43°C for 2 hr almost completely killed the larvae of *E. amabilis* and *H. pulverea* in broodlac spread over the floor. This, however, adversely affected the viability of the progeny and hence is recommended only for lac unfit for use as brood.

7 (a) Brestan® and Brestanol® in concentrations of 0·1 to 0·3 per cent were found to be safe to the 4, 10, 20 and 40-day-old lac insects and resulted in inhibition of feeding of the newly hatched larvae of the lac predators, *E. amabilis* and *H. pulverea*.

(b) Trials with three commercial preparations of *B. thuringiensis* showed that these were all highly toxic to the larvae of *E. amabilis* and *H. pulverea*.

(c) Bioresmethrin in concentrations of 0·003 to 0·015 per cent was found to be toxic to the 12-day-old lac larvae but the emulsifiers, namely, Dedenol super N, Polysorbate 80 and Hyoxid X100 at 0·05 per cent concentration were quite safe.

B. AGRONOMY AND PLANT GENETICS DIVISION

(a) RESEARCHES COMPLETED

1. The performance on the rooting response of *galwang* was most successful in March planting with the growth regulator mixture IBA+IPA at 100 ppm, whereas the June planting proved best for *bhalia*, *rain tree* and *pansura* with IPA+NAA at 50 ppm, IAA+NAA at 100 ppm and IBA+IAA at 50 ppm, respectively, in establishing large number of rooted plants.

(b) RESEARCHES ON HAND

1. The growing of groundnut with *bhalia* and *arhar* as intercrops showed no marked reduction in the yield of groundnut.

2. The rhizobium of *M. chappar* was found to be more fast growing than that of *M. macrophylla*.

3 (a). The maximum shoot length was recorded in *bhalia* bushes raised from seeds treated with NAA at 80 ppm.

(b) The application of GA increased the height of *Albizzia lucida* and *Moghania macrophylla* significantly over the control. The increase in height was 125·0 per cent in *A. lucida* with 80 ppm of GA and 30·0 per cent in *M. macrophylla* with GA at 40 ppm.

4 (a). The somatic chromosome number of some varieties of *Cajanus cajan* and of *Albizzia lucida*, *Albizzia lebbek*, *Acacia catechu* and *Samanea saman* were confirmed as 2n = 22, 26, 26, 26 and 26 respectively while conducting karyotype studies on them.

(b) Partial analysis of variance of chiasma frequency within and between nuclei was studied in thirteen *arhar* varieties which showed positive correlation in ten varieties and negative in three.

(c) Gamma treatment of *arhar* (Ranchi and Assam), *bhalia* and *salpan* showed that mitotic abberrations and number of micronuclei in the root and shoot meristems increased with the increase in dose which, however, decreased with lapse of time.

(d) The gamma irradiated seeds of *bhalia* and *salpan* showed that their root and shoot lengths decreased with the increase in dose.

(e) Changes in plant attributes of two *arhar* varieties (Ranchi and Assam) observed in M_1 generation after gamma irradiation of seeds showed that they decreased with increase in dose.

The flower buds collected from the M_1 generation plants raised after gamma irradiation of seeds showed that meiotic abberrations increased with the increase in dose.

(f) Changes in plant attributes of *bhalia* and *salpan* observed in the M_1 generation after gamma irradiation of seeds were found to return towards normality at lower doses in M_2 generation.

C. CHEMISTRY DIVISION

(a) RESEARCHES COMPLETED

1. Uncatalysed and catalysed kinetics, molecular weight-intrinsic viscosity relationship and polymolecularity of 16-hydroxypalmitic acid polyester were studied.

2. Graft copolymerization of shellac with ethylacrylate using potassium persulphate and with MMA using hydrogen peroxide as initiator was studied. Grafting was not noticed in both cases.

3. While studying the modification of shellac with epichlorohydrin, the experiments showed that dewaxed lac is better than the wax containing grades for its epoxidation. The sodium salt of shellac when reacted with epichlorohydrin in presence of catalyst yielded hard, glossy and flexible films which were resistant to water and some chemicals.

(b) RESEARCHES ON HAND

1. With a view to synthesizing macrocyclic molecules from aleuritic acid, two intermediates, viz. isoaleuritic acid and ω-bromo-9-hexadecanoic acid were prepared from aleuritic acid.

2. The hard resin obtained from *palas* lac on fractionation by urea-complex formation gave three fractions. One of the three fractions indicated the presence of jalaric, aleuritic, shellolic and epishellolic acids.

3. A quick method was developed to identify shellac in presence of other resins through spot test with fuchsin-sulphurous acid in the mother liquor after hydrolysis of shellac.

4. Attempts were made to optimize the hydrolytic process for depolymerization of shellac and to understand the mechanism of degradation reaction. It was found that lesser the degree of polymerization of substrate, the greater the degree of degradation.

5. Some of the properties of cation exchange resin prepared from sulphonated lac were compared with Amberlite resin. The cation exchange resin of shellac can be used up to 15 times without any deterioration in its performance.

6. The end products obtained by modifying total hydrolysed (refuse) lac with phthalic anhydride gave good performance when used in water-thinnable paint formulations. The paint can be stored for more than a year in air tight containers and no deterioration in the properties could be noticed.

The film properties of water-thinnable wash primer obtained from Rebulac modified with linseed oil fatty acids using zinc tetroxy chromate as pigment were studied. The films were flexible, water resistant and had good adhesion but poor storage stability which was improved by adding maleic anhydride.

7. The viscosity of the water-thinned shellac-emulsion paint did not change up to three months but thereafter some growth of fungus was observed which could be overcome by adding pentachlorophenol (0·5 per cent). The paint could be prepared on semi-pilot scale (2 gallons per batch). A patent has been applied for the process developed.

8. To impart anticorrosive properties to the shellac based primers in the course of applicaion by the electrodeposition technique, graphite was used as a conducting pigment to increase the film thickness. The films obtained were thicker but the adhesion was poor. Further improvement could not be brought about even by changing current density, voltage or *p*H.

9. Microencapsulation or coacervation technique was tried to use shellac as a coating material for Biotrol®. It was observed that more or less continuous wall had formed around the spore particles. The process had, however, no adverse effect on their viability.

10. A water-thinned shellac paint for internal decoration was developed by modifying ammoniated shellac with maleic anhydride or citric acid treated linseed oil with pigmentation. A patent has been applied for the process developed.

11. In order to assess the suitability of lac melamine varnishes as binder for the top layer of the decorative laminates, different types of papers were impregnated in lac melamine varnish and the laminates so obtained were smooth and hard.

12. Shellac could be cold blended with oxidizers and other ingredients to get into the form of putty which could be cured to get a rocket fuel with good mechanical properties and burning characteristics.

D. TECHNOLOGY DIVISION

(a) RESEARCHES COMPLETED

1. A simple method to separate the soft fraction of crude wax obtained from lac effluents, based on carrying out saponification with sodium hydroxide in aqueous medium, was developed. The soft fraction got saponified and remained in suspension while the other fraction separated as a solid mass. The solid fraction is much harder and possesses better properties.

2. The method developed to prepare pure lac dye was examined on semi-pilot scale. The dye so obtained had all the desired properties compared to the one prepared in small lots earlier.

(b) RESEARCHES ON HAND

1. With a view to finding out a solvent in place of spirit to dewax the lac, isopropyl alcohol was tried. The dewaxed lac, thus obtained, was lighter in colour but the yield was lower.

2. The new technique developed to bleach lac using a combination of sodium hypochlorite and hydrogen peroxide was examined on semi-pilot scale. The bleached lac, thus obtained, had all the desired properties compared to the one prepared in smaller lots.

3. The effect of incorporation of rosin-lac-ester to styrene-butadiene rubber (SBR) was studied. The ester acts as a processing aid and raises tensile strength, tear resistance and hardness of SBR.

4. In order to substitute coumarone-indene resin which is being imported for use in rubber compositions, shellac was tried and found better.

7. METEOROLOGICAL REPORT FOR THE YEAR 1973

The average meteorological data for each month were as follows:

Month	Mean barometric pressure mm	Mean maximum temp. °C	Mean minimum temp. °C	Mean dry bulb temp. °C	Mean wet bulb temp. °C	Mean humidity %	Mean sun shine hrs/day	Total rainfall mm	Highest maximum temp. °C	Lowest minimum temp. °C
January	709·5	26·2	10·3	21·0	15·3	53·7	8·14	12·2	31·0	5·5
February	709·4	27·4	12·9	22·5	16·5	54·0	7·58	28·0	33·0	7·0
March	706·8	31·9	15·3	26·6	16·8	35·2	8·17	38·6	39·0	11·3
April	702·7	39·3	22·1	33·2	21·2	33·0	9·03	28·4	42·0	18·0
May	700·6	39·1	23·4	32·2	24·0	49·5	8·38	21·8	45·0	20·0
June	698·9	34·7	24·0	29·6	24·6	66·3	—	198·7	39·0	21·5
July	697·9	29·3	22·8	26·2	24·3	85·7	—	370·6	32·2	21·5
August	699·8	29·5	22·6	25·7	24·3	89·8	3·77	368·7	31·5	21·0
September	702·2	28·9	21·9	25·6	24·3	89·9	3·51	462·2	32·0	21·0
October	705·8	28·0	19·1	24·8	23·0	85·2	5·13	264·0	32·5	14·0
November	708·6	25·7	12·9	22·2	18·8	72·0	7·34	28·3	28·0	8·5
December	710·4	22·9	8·2	19·1	15·3	66·7	8·19	1·1	25·5	3·5

The highest maximum temperature recorded was 45°C on 9th May and lowest minimum 3·5°C on 26th December. The total rainfall during the year amounted to 1822·6 mm, of which the monsoon (June to Sept.) rainfall was 1400·2 mm. The rainfall during the year was higher than that of 1972 (1320·5 mm). There were hail storms on 7th March, 17th April and 3rd May.

8. PERSONNEL

Sl. No.	Name of the Post	Sanctioned	Staff in position as on 31.12.1973
1	2	3	4
1.	Director	1	Dr. J. N. Chatterjea
	Entomology Division		
2.	Head, Division of Entomology	1	Dr. T. P. S. Teotia
3.	Entomologist	1	Dr. A. Bhattacharya
4.	Insect Geneticist	1	Sri N. S. Chauhan
5.	Jr. Insect Ecologist	1	Dr. B. P. Mehra
6.	Jr. Insect Parasitologist	1	Dr. C. P. Malhotra
7.	Jr. Physiologist	1	Sri A. H. Naqvi
8.	Jr. Entomologist	1	Vacant
9.	Sr. Research Assistant	11	(1) Sri R. S. Gokulpure (2) Dr. N. Majumdar (3) Sri S. G. Chowdhury (4) Sri A. K. Sen (5) Sri Beche Lal (6) Sri D. C. Srivastava (7) to (11) Vacant
10.	Instructor (Lac Cultivation)	1	Sri R. C. Mishra
11.	Research Assistant	9	(1) Sri Parimal Sen (2) Sri B. N. Sah (3) Sri J. M. Das Gupta (4) Sri R. C. Maurya (5) Sri Y. D. Mishra (6) Sri M. L. Bhagat (7) Sri S. K. Jaipuriar (8) Sri Jawahir Lal (9) Sri M. K. Chowdhury
12.	Artist-cum-Photographer	1	Sri R. L. Singh
13.	Jr. Artist-cum-Photographer	1	Sri Pyare Das
14.	Jr. Field Assistant	1	Vacant
15.	Fieldman	8	(1) Sri S. N. Sharma (2) Sri H. R. Munda (3) Sri Sant Kumar (4) Sri R. S. Maliya (5) Sri K. C. Jain (6) Sri B. P. Sah (7) Sri S. S. Prasad (8) Vacant
16.	Insect Collection Tender	1	Sri Md. Ali Ansari
17.	Laboratory Assistant	7	(1) Mrs. Namita Nandi (2) Sri A. Hussain (3) Sri R. D. Pathak (4) Sri R. C. Singh (5) to (7) Vacant
18.	Store and Plantation Assistant	1	Sri G. Lakra

Agronomy and Plant Genetics Division

1.	Agronomist	1	Dr. Sohan Lal
2.	Jr. Arboriculturist	1	Sri B. K. Purkayastha
3.	Jr. Plant Geneticist	1	Sri P. Kumar
4.	Sr. Research Assistant	1	Vacant
5.	Fieldman	1	Sri B. D. Tiwari
6.	Laboratory Assistant	1	Sri D. D. Prasad

Chemistry Division

1.	Head, Division of Chemistry	1	Dr. S. C. Sengupta
2.	Scientist (Decorative)	1	Sri Shravan Kumar
3.	Organic Chemist	1	Dr. P. R. Bhattacharya
4.	Jr. Chemist (Polymer)	1	Sri A. Kumar
5.	Jr. Chemist (Physical)	1	Vacant
6.	Jr. Technologist (Surface Coating)	1	Vacant
7.	Sr. Research Assistant	6	(1) Sri P. C. Gupta (2) Sri T. R. Lakshmi-narayanan (3) Sri A. Rahman (4) Sri S. K. M. Tripathi (5) Sri R. K. Banerjee (6) Vacant
8.	Research Assistant	11	(1) Dr. August Pandey (2) Sri M. Mukherjee (3) Sri A. K. Dasgupta (4) Sri B. C. Srivastava (5) Sri N. Prasad (6) Sri R. N. Majee (7) Sri K. M. Prasad (8) to (11) Vacant
9.	Glass Blower	1	Sri S. K. Dey
10.	Laboratory Assistant	10	(1) Sri B. B. Chakravorty (2) Sri Nagendra Mahto (3) Sri Umeshwar Sahay (4) Sri B. P. Keshry (5) to (10) Vacant

Technology Division

1.	Technologist	1	Dr. B. B. Khanna
2.	Jr. Technologist (Processing)	1	Sri A. K. Ghosh
3.	Jr. Technologist (Factory)	1	Sri P. K. Ghosh
4.	Sr. Research Assistant	1	Sri R. K. Banerjee
5.	Research Assistant	4	(1) Sri M. Islam (2) Sri Radha Singh (3) Sri B. P. Banerjee (4) Sri Ramesh Prasad
6.	Laboratory Assistant	2	(1) Sri N. Minz (2) Sri M. K. Singh

Extension Division

1.	Scientist (Shellac Utilization)	1	Dr. S. K. Saha
2.	Jr. Scientist (Shellac Utilization)	1	Vacant
3.	Asstt. Scientist (Production)	1	Vacant
4.	Sr. Analyst	1	Sri L. C. Mishra
5.	Analyst	2	Vacant
6.	Laboratory Assistant	2	(1) Sri D. Runda (2) Sri G. M. Borker
7.	Museum Assistant	1	Vacant

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