INDIAN LAC RESEARCH INSTITUTE
NAMKUM, RANCHI, BIHAR

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Contents

Introduction

The Indian Lac Research Institute came into existence as a result of the recommendation of a two-man enquiry committee 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 alround improvement. The report of this committee was published in 1921 in which they observed, *inter alia*, that the two major ills from which the lac trade was then suffering, namely, liability to violent price fluctuations and adulteration in times of short supply, could be cured only by increased outturn. For this, they suggested that recourse should be taken to intensive cultivation by scientifically tested methods, rather than to extensive cultivation. In order to implement this suggestion, members engaged in the lac trade at that 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 the Association in 1931. The Committee maintained the Institute till March 13, 1966. With the abolition of the Committee on this day, the Institute was taken by the Indian Council of Agricultural Research from April 1, 1966, and is now functioning under this Council.

The Institute is situated at Namkum, about nine kilometres south-east of Ranchi. The laboratories of the Institute consist of three fair-sized separate buildings housing the Entomology Laboratory, the Chemistry Laboratory, and the experimental factory. The library adjoins the entomology building. The administrative section and museum are housed in another block. The waterworks, workshop, gas plant, etc., are located in small constructions between the main Chemistry and Entomology laboratories. Due to the paucity of accommodation, the audit and accounts section and one unit of the administrative section are temporarily accommodated in two small rooms, adjoining the workshop, previously occupied by the Chemistry Division.

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

The Institute is headed by the Director who also functions as Head of the Chemistry Division. The head of the Division of Entomology is the Entomologist. This report covers the period April 1, 1966–December 31, 1966.

OBJECTIVES AND STRUCTURE

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

The present structure of the Institute is indicated in the following plan :

Director

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

Visitors. This Institute has always been a regular attraction to most visitors to Ranchi, particulary scientists and technologists. During the period under report also, it had the usual complement of visitors, including students and trainees from different colleges and institutions, officials and others including the delegates who attended the soil wing meeting at the Ranchi Agricultural College. Other distinguished visitors during the year included the following :

1. Smt. Kamala Devi Chattopadhyaya —Chairman, All India Handicrafts Board
2. Dr. J.S. Kanwar —Deputy Director-General (S.A.I.E.), Indian Council of Agricultural Research
3. Swami Gambhirananda —General Secretary, Ramkrishna Math and Mission, Belur (W.B.)

Collaboration with other institutions. Apart from work within its own premises, the Institute has always sought to take advantage of technical know-how and facilities available in other institutions also for the furtherance of its objectives. A research project is in progress since 1960 under which the constitution of lac is being studied simultaneously at the Chemistry Laboratory of the Delhi University under the guidance of Prof. T.R. Seshadri, F.R.S.and at the National Chemical Laboratory, Poona, under the guidance of Dr. Sukh Dev. In addition, the constitution of lac dye is also being investigated at the National Chemical Laboratory, Poona, under the guidance of Prof. K. Venkataraman and development of shellac based leather finishes at the Central Leather Research Institute, Madras, both under separate schemes. The Institute is continuing to get co-operation from the Indian Institute of Technology, Kharagpur, in its work on shellac and rubber combinations as during the previous years.

The Institute also takes advantage of international technical co-operation schemes to provide specialised training to its employees. During the year under report, Shri B.P. Mehra, Scientific Officer (Cultivation) was deputed to Canada, Department of Agricultural Research Station, St. Jean, for one year under the Colombo Plan. This period had since been extended by another six months on their recomendation.

The Institute continued to collaborate, with the Indian Standards Institution in the formulation of Indian standards for lac and lac products and allied materials.

A scheme of co-operative research was taken up during the year with the Jute Technological Research Laboratories, Calcutta, with a view to developing newer uses of lac in conjunction with jute.

Advisory services. The Institute provides technical assistance to all those interested in the cultivation, processing, grading and utilization of lac. During the year, technical assistance was provided, among others, to the Bihar State Forest Department in the setting up and maintenance of their *Kusmi* brood-*cum*-demonstration farm at Maheshpur (Ranchi District) and to the Bihar State Lac Co-operative Marketing Federation Limited, for their purchase and processing operations.

In addition, two courses of training of six months' duration are also provided (i) on improved methods of lac cultivation, and (ii) on industrial uses of lac. The training is given to candidates deputed by the Central and State Governments and by industrial undertakings.

For the benefit of the trade and industry, the Institute maintains regional analytical laboratories in the major lac processing centres of the country. During the period under report, three laboratories were functioning, namely, one each at Namkum (Ranchi District, Bihar), Balarampur (Purulia District, West Bengal) and Gondia (Bhandara District, Maharashtra).

Library. The number of books and bound volumes of journals acquired during the period under report was 38.* This brought the total number of books and bound volumes of journals in the library, as on December 31, 1966, to 11,587.

In addition, some miscellaneous publications, microfilms and reports were also received.

Staff club. The staff club continued its activities as usual.

Finances. Since its inception, lac research was financed through a cess levied on all exports of lac. Since 1962–63, however, some grants were also provided by the Government of India, as the income from the cess was found inadequate. Since the Institute has been taken over by the Indian Council of Agricultural Research from April 1, 1966, it is being wholly financed by the Council.

The actual expenditure during 1966–67 was Rs. 9.87 lakhs.

*Many journals received during the previous year could be got bound and accessioned only after December 31. These, therefore, have not been included in the above total.

Progress of Research

A. ENTOMOLOGY DIVISION

Work on the various items of the approved research programme of the Division, unfinished at the end of last year, was continued during the period under report.

The staff position which was difficult deteriorated further due to the resignation of a few more research assistants. The post of Scientific Officer (Insect Genetics) was filled up on an *ad-hoc* basis, but the post of Scientific Officer (Arboriculture) fell vacant as the incumbent reverted to his parent department. It was not filled. Two other posts of Scientific Officers (of Biology and Insect Physiology) also remained vacant throughout the period.

For the second successive year, the weather was perhaps the worst in living memory with unprecedented drought in the major lac-producing areas in the country and particularly in Bihar. The monsoon was practically absent and the winter rains did not occur timely. These conditions also contributed adversely to the progress of the experiments. Nevertheless, progress was maintained as far as possible.

Among the more important findings during the year, particular mention may be made of the following conclusions arrived at on completion of the appropriate studies. It was established that the maximum yield of stick lac is obtained in the *Katki* crop on *ber* by using two metres of brood for every 25 metres of inoculable shoots. It was also established that in raising a plantation of *bhalia* (*Moghania macrophylla*) bushes, the best height of the bush as well as growth and length of the shoots are obtained by transplanting, in July, the seedlings raised in April, at the rate of two per pit.

Other notable findings are that (i) it is not practicable to cut brood (necessary for purposes of despatch to distant places) from *palas* and *ber* earlier than two weeks before the anticipated date of swarming, (ii) when pruning-*cum*-harvesting is carried out during April–May and brood lac used at the rate of 400 g per tree, yield of the crop (sticklac) is highest when it is completely harvested as *ari* between the April 15, and 20, (iii) when the pruning-*cum*-harvesting is carried out during October–November, it is preferable to use light inoculation at the rate of about 100 g of brood per tree during the subsequent October–November and to harvest the crop completely a year later, allowing self-inoculation during intervening June–July; this results in the highest yield of broodlac as well as sticklac, (iv) the maximum yields of sticklac are obtained from *bhalia* bushes when spaced at 1.22×1.22 metres, and also when organic manure is applied at the rate of 2 kg per bush, (v) *galwang* (*Albizzia lucida*) is a good alternate host for raising the *Kusmi* strain of lac during the *Jethwi* crop and (vi) *Bacillus thuringiensis* appears to be an efficient controlling agent for the two major predators of the lac insect.

(a) RESEARCHES COMPLETED

1. **Determination of optimum density of larval settlement for *ber* in *Katki* season.** The studies were conducted again on the trees which had not responded to pruning for raising the previous *Katki* crop. Twelve trees each were inoculated in July 1966 with 'half normal', 'normal' and 'double normal' rates of brood (normal rate being fixed arbitrarily at 1 metre of healthy brood for 25 metres of inoculable shoots), and the crop harvested during October–November 1966. The data collected are brought out in Table 1 below :

From the crop data set out in Table I, it will be seen that the maximum yield of sticklac (17.15 kg) was obtained with the heaviest brood rate tried, although the best 'ratio' of brood used to brood obtained (multiplication of brood) (1 :3.85) has been with the lightest inoculation.

2. **Working out plantation technique of raising** *bhalia* (*Moghania macrophylla*). Under this experiment, both the methods, viz., (a) direct sowing of seeds, and (b) transplanting of seedlings were studied. Sub-factors studied were two different times of sowing with two seed-rates. In addition, three different ages of seedlings with two plant rates for transplanting were also considered. Thus, there were 10 treatments replicated four times, making a total of $10 \times 4 = 40$ plots, each plot having 15 pits.

The seedlings were transplanted in July and observations on the height of the plants as well as the number and length of shoots developed were recorded each month till the time of inoculation. From the data collected during the past three years, during which consistent results were obtained, it has been finally confirmed that the most satisfactory procedure is to transplant in Júly, the seedlings raised in April, at the rate of two per pit.

(b) RESEARCHES IN HAND

1. **Studies to ascertain the most appropriate time for harvesting of *ber* broodlac for crop inoculations.** The object of this study is to determine how early, prior to the actual date of larval emergence, broodlac from *ber* can be cut and it will still be satisfactory for inoculation. This is of importance where broodlac has to be cut in advance for despatch to distant destinations for use there. A similar study on *palas* is also being carried out as reported last year (*Annu. Rep.* 1965–66).

For the present study, 5 kg each of broodlac were harvested three, two, and one week before and on the actual date of larval emergence (on the 7th, 14th, 24th and 26th October 1966 respectively). Each of these lots (A,B,C, and D) was used for inoculating five trees.

There was very poor settlement on the trees inoculated with the first lot (A) and all the insects died by November. There was also greater mortality in B than in C and D. The condition of the crops in C and D was satisfactory till the end of the year. Harvesting is to be carried out in October 1967.

2. **Determination of optimum density of larval settlement on *palas* in hot areas (at Kundri).** The experiment was continued for the third year on the

TABLE I. OPTIMUM DENSITY OF LARVAL SETTLEMENT FOR *ber* IN *Katki* SEASON
Crop data—*Katki* 1966

12 trees were used for each brood rate

Brood rate	Brood used		Yield obtained						Ratio of brood used to brood yield		Ratio of brood used to total yield	
			Lac stick			Sticklac						
	Lac stick (kg)	Sticklac (scraped lac from col. 2. (kg)	Brood (kg)	Rejected (kg)	Total (kg)	Brood (scraped lac from col. 4) (kg)	Rejected (scraped lac from col. 5) (kg)	Total (scraped lac from col. 6) (kg)	Lac stick (col. 2 :4)	Sticklac (col.3 :7)	Lac stick (col.2 :6)	Sticklac (col. 3 :9)
1	2	3	4	5	6	7	8	9	10	11	12	13
0.5 N	4.2	1.5	16.3	33.3	49.6	5.6	4.3	9.9	1 :3.85	1 :3.73	1 :11.8	1 :6.6
N	8.4	2.5	16.2	41.8	58.0	6.45	7.9	14.35	1.1.93	1 :2.6	1 :6.9	1 :5.76
2 N	16.8	4.65	17.45	53.25	70.7	6.9	10.25	17.15	1 :1.04	1 :1.46	1 :4.15	1 :3.74

lines reported earlier (*Annu. Rep.* 1964–65). There were, in all 14 groups (A to N) with 10 trees in each group. Groups A to H had been given, in October 1965, 'heavy' inoculation, i.e., with broodlac, ranging from 1.5 kg to 5 kg (for 10 trees) with an increase of 0.5 kg of brood from treatment to treatment. Groups I to N were given 'light' inoculation, i.e., with 0.52 kg to 1.5 kg of brood (for 10 trees) with an increase of 0.25 kg per treatment.

Groups A to H were harvested in April 1966, and the rest (I to N) were left for self-inoculation in June–July for harvesting completely in October-November 1966, i.e., one year after inoculation. The average yields of sticklac per tree in A to H were 0.072, 0.117, 0.134, 0.115, 0.142, 0.125, 0.135 and 0.142 kg respectively. In regard to Groups I to N, however, due to excessive drought in the area, all the insects died and there was no crop.

3. **Studies on the proper time of harvesting-*cum*-pruning of *palas* within April-May.** Systematic studies on *palas* have shown that the maximum yield of lac is obtained by harvesting the crop as *ari* in April or May, which are also the months for pruning the trees for *Baisakhi* inoculation. Experiments were, therefore, initiated in 1963 at Kundri to determine if this harvesting cannot also be utilised to serve as pruning in order to cut down the cost of cultivation. The following schedules continued to be under study with 40 trees under each.

A—Complete pruning-*cum*-harvesting in the first week of April.

B—Complete pruning-*cum*-harvesting between April 15 and 20.

C—Partial (new shoots were left uncut) pruning-*cum*-harvesting between April 15 and 20.

D—Complete pruning-and-harvesting between May 15 and 20.

E—Partial (as in C above) pruning-*cum*-harvesting between May 15 and 20.

The trees inoculated during October–November 1965 with brood at the rate of 4 kg per 10 trees were pruned and harvested as per schedule.

In Table II below are reproduced the data on shoot growth and in Table III the crop yields.

TABLE II. STUDIES ON THE PROPER TIME OF HARVESTING-*cum*-PRUNING OF *palas* IN APRIL–MAY

Shoot measurement data

Treatment	Total No. of shoots developed	Total shoot length in metres	Av. No. of shoots per tree	Av. shoot length per tree in metres
A	430	219.94	35.83	18.33
B	625	367.17	52.08	30.59
C	745	387.39	62.08	32.28
D	522	224.15	43.50	18.68
E	409	179.38	34.08	14.95

TABLE III. STUDIES ON THE PROPER TIME OF HARVESTING-*cum*-PRUNING *palas* IN APRIL–MAY

Crop data—*Baisakhi* 1965–66

40 trees were used under each treatment

Treatment	Brood used: Lac stick kg	Brood used: Sticklac (Scraped lac from col. 2) kg	Yield: Lac stick kg	Yield: Sticklac (scraped lac from col. 4) kg	Ratio of brood used to yield obtained: Lac stick (col. 2 :4)	Ratio of brood used to yield obtained: Scraped lac (col. 3 :5)	Yield of sticklac (scraped lac) per tree
1	2	3	4	5	6	7	8
A	16	1.062	84.500	7.500	1 :5.28	1 :7.06	0.187
B	16	1.290	89.500	9.600	1 :5.59	1 :7.44	0.240
C	16	1.466	74.000	8.750	1 :4.62	1 :5.96	0.218
D	16	1.183	60.000	6.100	1 :3.75	1 :5.15	0.152
E	16	1.218	57.500	5.975	1 :3.59	1 :4.90	0.149

It will be seen that the maximum number of shoots with the highest total shoot length developed under B and C, which also recorded much higher yields of sticklac. These results agree well with those obtained in the previous years. Fresh inoculations for the next trial during 1966-67 were carried out in October 1966. After the harvest in 1967 the experiment will be concluded.

4. **Studies on the proper time of harvesting-*cum*-pruning of *palas* within October–November.** The object of this study is the same as in 5 above, except that it is for the October–November season. The following schedules were continued with 30 trees in each treatment with replications so that the total under each treatment was 150 trees.

A—Heavy inoculation (broodlac used approximately 400 g per tree) in October–November and complete harvesting in April.

B—Medium inoculation (broodlac used approximately 200 g per tree) in October–November, allowing self-inoculation in the following June–July and complete harvesting in next October–November, that is, one year after inoculation.

C—Light inoculation (broodlac used approximately 100 g per tree), the rest being the same as B above.

Table IV below shows the results of the study during 1965–66, which is the third year of the investigation.

It will be seen that the highest yield of brood as well as sticklac was obtained from the trees inoculated lightly (Schedule C).

TABLE IV. STUDIES ON THE PROPER TIME OF HARVESTING-*cum*-PRUNING OF *palas* IN OCTOBER–NOVEMBER

Crop data

Treatment	Brood used		Yield obtained						Ratio of brood used to brood yield		Ratio of brood used to total yield		Yield per tree
			Lac stick			Sticklac							
	Lac stick (kg)	Sticklac (scraped lac from col.2) (kg)	Brood-lac (kg)	Reject-ed lac (kg)	Total (kg)	Brood lac (scra-ped lac from col. 4) (kg)	Rejected (scraped lac from col. 5) (kg)	Total (scraped lac from col. 6) (kg)	Lac stick (col.2 :4)	Stick lac scraped lac (col. 3 :7)	Lac stick (col. 2 :6)	Stick lac (scraped lac col. 3 :9)	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
A	50	3.200	—	230.500	230.500	—	23.600	23.600	—	—	1 : 3.84	1 : 7.37	0.157
B	30	1.900	26.000	93.000	119.000	2.284	13.400	15.684	1 :0.86	1 :1.20	1 :39.66	1 : 8.25	0.104
C	15	1.550	81.000	136.000	217.000	8.988	20.900	29.888	1 :5.40	1 :5.79	1 :14.40	1 :19.28	0.192

Fresh inoculations for the fourth year (1966–67) were carried out in October–November 1966. After the harvest in 1967, the experiment will be concluded.

5. **Evolution of cultivation practice for *palas* at Kundri (direct comparison of newly evolved plan with villagers' method).** The study was continued for the third year in succession comparing two newly evolved plans with the villagers' method. Cultivation was carried out on 500 trees under each of the following schedules :

A—Heavy inoculation in October–November and complete harvesting in the following April.

B—Light inoculation during October–November, allowing self inoculation the following June–July and complete harvesting during the subsequent during October–November, that is, one year after the inoculation.

C—Heavy inoculation in October–November and partial harvesting (leaving sufficient lac for brood) successively in April and during October–November for a number of years without any fresh inoculation.

Inoculations for schedules A and B were carried out in October 1965. For C, the crops were collected from the trees which had the original inoculation in 1963 and from which crops had been partially harvested ever since in April and October–November, without any fresh inoculation.

The 500 trees under A were harvested as per schedule in April 1966 and those in B in October 1966. Since there was very little lac on the trees in treatment C (which has been repeatedly harvested in April 1964, October 1964, April 1965, October 1965 and April 1966) it was considered that it need not be harvested as per schedule. Instead, these trees were given a fresh inoculation in October 1966 with 150 kg of broodlac (as the villagers usually do).

The crops were affected adversely due to prolonged drought prevailing in the area. So, no conclusions could be drawn. However, fresh inoculations were carried out in October 1966 for the next crop.

6. **Studies to ascertain the most appropriate time for harvesting of *palas* broodlac for crop inoculations.** These studies on *palas* are with the same objective as described for *ber* under Item 3, namely, to determine how early broodlac can be harvested without damage to its suitability for lac crop inoculation. In this case, samples of broodlac were harvested at weekly intervals from September 16, 1966 up to the time of larval emergence which occurred on November 4. These samples were used for inoculating 10 trees each at the time of larval emergence. There were thus eight samples harvested on September 16, 23, and 30, October 6, 13, 20 and 27 and November 4 (Treatments A to H), the last being the control.

Emergence did not take place from A, B, C and D, i.e., the brood harvested earlier than four weeks before larval emergence. Poor emergence occurred from E, i.e., brood cut three weeks earlier, but all the larvae died soon after settlement. Samples harvested within a fortnight before actual larval emergence(F and G) produced normal emergence of larvae and their settlement was also good.

In the same study during the previous year also, only F, G and H survived.

They continued to develop up to May–June this year (1966) when they were severely affected due to prolonged drought and severe summer. The crops were therefore extremely poor.

7. **Evolution of cultivation schedules and determination of optimum density of larval settlement on** *M. macrophylla* **for growing** *Aghani* **and** *Jethwi* **crops.** It was reported last year (*Annu. Rep.* 1965-66) that 5,000 seedlings were proposed to be raised and transplanted in June–July 1966. Unfortunately, due to poor growth of seedlings and non-availability of manure, transplanting could not be done. Fresh attempts will be made next year.

8. **Spacing trials on** *M. macrophylla* Three spacings, namely, 1.83 meters × 1.83 metres (6′×6′), 1.83 metres × 1.22 metres (6′×4′) and 1.22 metres × 1.22 metres (4′×4′) as reported earlier continued to be under trial in three coupes according to the layout already given (*Annu. Rep.* 1965–66.)

SHOOT STUDY: The plants under Coupe I showed linear growth till the end of October 1966, the growth being most vigorous from June to August. Later, however, during May–June 1966, a large number of smaller shoots and a few of

TABLE V. SPACING TRIALS OF *M. macrophylla*

Shoot measurement data

Coupe No.	Treatment	Spacing	Plant height (cm)	No. of shoots	Total shoot length (cm)
I	A	1.83 × 1.83 sq. metres (6′×6′)	131.2	9.7	654.5
	B	1.83 × 1.22 sq. metres (4′×4′)	157.2	14.00	1067.0
	C	1.22 × 1.22 sq. metres (4′×4′)	148.8	12.7	811.0
II	A	1.83 × 1.83 sq. metres (6′×6′)	158.3	12.4	800.6
	B	1.83 × 1.22 sq. metres (6′×4′)	150.5	9.1	717.9
	C	1.22 × 1.22 sq. metres (4′×4′)	145.8	8.1	657.4
III	A	1.83 × 1.83 sq. metres (6′×6′)	51.2	2.7	96.0
	B	1.83 × 1.22 sq. metres (6′×4′)	62.3	3.4	131.5
	C	1.22 × 1.22 sq. metres (4′×4′)	55.8	3.0	123.8

the plants themselves dried up apparently due to lack of moisture in the soil. Inoculation will be carried out for the *Jethwi* crop in January 1967 in this coupe.

The plants raised from transplanting in July 1965 in Coupe II resumed growth from March 1966, which continued till June when the plants were inoculated for raising the *Aghani* 1966–67 crop. After this, the growth of the plants appeared to have stopped.

Regarding the crop, however, at the early stages, the development was good. This also suffered later considerably due to attack of predatory insects. There has been a mortality of smaller plants which could not sustain the high density of insect population during the period of unusual drought which continued till the end of October. Presumably, the high population of insects caused rapid depletion of plant nutrients in the soil and as a result the plants died.

Growth of the plants raised from transplanting in July 1966 in Coupe III was very poor compared to that of plants in Coupes I and II and ceased altogether after October 1966.

The data relating to the height and number of shoots developed and total shoot length are presented in Table V.

It will be seen that in Coupe II, which was the coupe to be inoculated, growth of bushes and shoots was the best in treatment A.

9. **Effect of N P K on the yield of lac on** *Moghania macrophylla*. **Trials with organic and inorganic fertilizers.** For evaluating the fertilizer requirements and also the effect of the different constituents on the yield of lac, the experiment laid out in 1965 on a simple randomised block design has been in operation in each succeeding lac crop. In the *Jethwi* 1966 crop, the following treatments each with 10 bushes and four replications were under trial.

Treatment	*Manure*	*Dose*
A	N P K	Normal
B	N P K	Double normal
C	Organic	Normal
D	Organic	Double normal
E	No manure	—

N P K were supplied in the form of ammonium sulphate, superphosphate and muriate of potash. The normal rates were 50, 100 and 40 kg respectively per acre (1,800 bushes).

For organic manure, farmyard manure was used, the normal rate being 18 quintals per acre.

The crop in the *Jethwi* 1966 season suffered considerably due to the wilting of plants during summer.

Despite this, the crop data (Table VI) showed significant increases in the yield of lac with manuring. The differential effects of organic and inorganic manures, if any, however, are yet to be assessed since no consistent trend was observed.

TABLE VI. EFFECT OF N P K ON THE YIELD OF LAC ON *M. macrophylla*

Treat-ment	Lac stick				Sticklac (scraped lac)			
	Brood used (kg)	Brood yield (kg)	Total yield (kg)	Brood to yield ratio (kg)	Brood used (kg)	Total yield (kg)	Brood to yield ratio	Yield per plant (kg)
A	6.0	3.7	14.5	1:2.4	3.1	2.3	1:0.7	57.5
B	6.0	4.5	18.3	1:3.1	3.2	2.9	1:0.9	72.5
C	6.0	3.9	15.7	1:2.6	2.9	2.5	1:0.8	62.5
D	6.0	6.2	21.3	1:3.5	3.2	3.6	1:1.1	90.0
E	6.0	2.6	13.6	1:2.3	3.1	1.7	1:0.5	42.5

Fresh inoculations of the bushes for the next trial in the *Aghani* 1966–67 crop were carried out in July 1966.

10. **Evolution of cultivation practice for *kusum* at Hesal for maximum crop production at minimum cost and working out economics.** The experiment designed to determine a more profitable cultivation practice for *kusum* was started at Hesal in 1961. As in previous years, the following cultivation schedules involving different periods of rest to *kusum* were studied during the period under report.

Treatment	Period of years rest	Cultivation practice	No. of coupes	Number of trees in each coupe
A_1	1	Inoculation in June–July, allowing self-inoculation in January–February and complete harvesting in June–July.	2	15
A_2	1	Inoculation in January–February, allowing self-inoculation in June–July and complete cropping in January–February	2	15
B_1	2	Same as A_1	3	15
B_2	2	Same as A_2	3	15
C (control)	1.5	Complete cropping after six months	4	15

A_1, A_2, B_1 and B_2 are new schedules and C the practice in vogue. In A_1 and A_2 the crop was raised on one-year-old shoots and in B_1 and B_2 on two-year-old shoots. The harvesting of the crop was carried out only once after two consecutive crop seasons, allowing self-inoculation in the intervening January/February or June/July period. Accordingly, the brood requirements for trees under A_1 and A_2 was cut down to half and in B_1 and B_2 to three-fourths of the normal rate for trees under C. Heavy expenditures involved every six months in brood lac, inoculation and harvesting, etc., are thus avoided in the new schedules.

LAC CROPS

Aghani 1965-66-*cum*-Jethwi 1966. It was reported (*Annu. Rep.* 1965–66) that during July 1965, poor crop was existing on five trees in the first coupe of treatment A_1 and eight trees in second coupe of treatment B_1 which were to be completely harvested in July 1966. Only five trees in the first coupe of treatment C which were inoculated along with, was harvested in January/February 1966 and was reported last year. In the intervening period, inoculations were carried out in the second coupe of C which was harvested in July 1966 also. Total scraped lac (sticklac) yield from 15 trees in this coupe was 289.30 kg.

Jethwi 1966-*cum*-Aghani 1966-67. It was also reported that all the 45 trees, i.e., 15 each in coupes A_2I and B_2II along with C_2II (please see above) were inoculated during January/February 1966. The crops in A_2I and B_2II are to be harvested in January 1967 alongwith that in C III which was inoculated in July 1966 as per schedule of operation. A very good crop is expected during January/February 1967.

Aghani 1966-67-*cum*-Jethwi 1967. During July 1966, inoculations were carried out also on the trees in A_1 II and B_1 III which are to be ultimately harvested in July 1967 along with those in Coupe I which will be inoculated during January–February 1967.

It was indicated earlier (*Annu. Rep.* 1965–66) that due to extremely poor periods during 1964 and 1965, the progress of our experiment was hampered considerably. At this stage no comparison is feasible nor any conclusion possible. This has to wait till at least three sets each of the data are available. These will be in January/February 1967, 1968 and 1969 and June/July 1967, 1968 and 1969. Since the treatments are now in regular sequence it is expected that from now onwards regular crop data will be available unless there is a major failure.

11. **Studies on training of major lac hosts, e.g.,** *palas* (*Butea monosperma*) *ber* (*Zizyphus mauritiana*), *kusum* (*Schleichera oleosa*) *galwang* (*Albizzia lucida*) **and rain tree** (*Samanea saman*) **into bushes.** Studies were continued to examine the possibility of training the conventional lac host trees into bushes and the suitability of such trained bushes for cultivation of lac.

Palas, ber, kusum and *galwang* were tried. Of these *galwang* and a set of *ber* were successfully trained and the trained bushes used for lac cultivation. *Palas* and *kusum* are still in the process of being trained. Some of these, however, were also brought under lac cultivation.

Data obtained relating to growth responses are shown in Table VII and the crop results in Table VIII.

TABLE VII. STUDIES ON TRAINING OF LAC HOSTS

Shoot measurement data

Host plant	Month and year of coppicing/ harvesting	Primaries		Secondaries		Observation
		No. per bush	Total length (cm)	No. per bush	Total length (cm)	
Palas	April 1966	14.8	622.8	—	—	Plants inoculated in October 1966
Ber	May 1966	8.0	1090.6	50.6	2453.2	The primaries and secondaries developed from coppiced bushes and attained maximum length by the end of October 1966 and thereafter the growth was arrested.
Kusum	February 1966	7.3	627.4	—	—	The shoots arisen out of the coppiced plants in February–March 1966 had shown second phase of growth in length and thickness in August–September without developing secondaries.
	July 1966	5.6	213.6	—	—	The primary shoots that had developed in August continued to grow linearly till the end of September and growth ceased thereafter.
Galwang (*A. lucida*)	July 1965	14.5	2303.6	58.3	5085.0	The second phase of growth has been observed from March to end of August. Since then no further growth was observed but some of the thin shoots got dried up during the period.
	July 1966	9.2	646.4	—	—	The shoots arisen out of the coppiced bushes continued to grow satisfactorily till the end of October 1966.

TABLE VIII. STUDIES ON TRAINING OF LAC HOSTS

Crop data

Name of the host plant	Crop and year	No. of bushes	Lac sticks					Stick lac (scraped lac)				Remarks
			Brood used (kg)	Brood yield (kg)	Total yield (kg)	Brood yield ratio	Percentage of selected brood broodlac	Brood used (kg)	Total yield (kg)	Brood to yield ratio	Yield per bush	
Palas	*Baisakhi* 1965–66	50	11.5	28.4	34.4	1:3.0	82.6	2.3	7.3	1:3.2	146	
	Katki 1966	75	13.4	7.1	22.1	1:1.7	32.1	2.7	6.2	1:2.3	82.6	
Galwang (*A. lucida*)	*Baisakhi* 1965–66 (set I)	80	12.5	22.0	40.5	1:3.2	54.3	2.9	8.6	1:3.0	172	Alternated with *ber* for *Katki* crop
	Baisakhi 1965–66 (set II)	20	14.3	26.0	36.0	1:2.5	72.3	2.3	7.0	1:3.0	350	Alternated with *M. macrophylla* for *Katki* crop
Ber	*Katki* 1966	100										Crop failed
Kusum	*Jethwi* 1966	25	5.0	4.6	9.6	1:1.9	47.9	2.2	2.5	1:1.1	100	
Bhalia (*Moghania macrophylla*)	*Katki* 1966 (set I)	60	8.0	8.3	23.3	1:2.9	35.6	1.4	3.9	1:2.8	65.0	Alternated with *A. lucida* for *Baisakhi* crop
	Aghani 1966–67 (set II)	25	4.6									Alternated with *kusum* for *Jethwi* crop

*The crop did not mature with in December 1966 and, therefore, was not included.

It will be seen that the results with *galwang* in particular appear very encouraging.

12. **Finding out alternate hosts for** *Kusmi* **strain of lac insect and conducting cultivation experiment on them** (*e.g.*, *Albizzia lucida*, *Ougeinia oojeinensis*, *Ficus* sp., *Moghania chapper*, **rain tree, etc.**). The two hosts tried were *galwang* (*Albizzia lucida* and *sandan* (*Ougeinia oojeinensis*). Both were tried to alternate with *kusum* as well as an alternate for *kusum* as follows:

(i) IN ALTERNATION WITH *Kusum*: *Galwang* and *sandan* were studied as hosts for raising the *Jethwi* crop in alternation with *kusum* on which the *Aghani* crop was raised.

The crop data for *Jethwi* 1966 (Table IX set I) revealed that both these performed well in this season. Brood from these was used to inoculate *kusum* for raising the *Aghani* 1966–67 crop, which is progressing satisfactorily.

(ii) USE OF *Galwang* AND *Sandan* AS ALTERNATIVES FOR *Kusum*, I.E., FOR RAISING THE *Aghani* AND *Jethwi* CROPS CONTINUOUSLY WITHOUT ANY ALTERNATION. The *Jethwi* 1966 crop on *galwang* was rather poor due to patchy settlement by lac larvae (Table IX set II). The brood obtained was again utilised to inoculate another set of the same host for raising the *Aghani* 1966–67. The crop is progressing quite well like that on *kusum* itself.

(iii) USE OF *Galwang* IN ALTERNATION WITH *Bhalia* (*M. macrophylla*) FOR RAISING *Jethwi* AND *Aghani* CROPS AND VICE VERSA.

Since *galwang* and *bhalia* have proved to be good *Kusmi* hosts for *Jethwi* and *Aghani* crops respectively, the two were tried in alternation with each other for sustained cultivation of *Kusmi* lac. The crop data obtained are presented in Table IX.

It will be seen that *galwang* again proved a good host for raising the *Jethwi* 1966 crop, yielding a ratio of 1 :3.2 for brood used to yield obtained, which compares favourably with that from *kusum* (set III).

The *Jethwi* 1966 brood from *galwang* was used to inoculate *bhalia* for raising the *Aghani* 1966–67 crop. The crop was progressing satisfactorily.

GENETICAL AND BREEDING STUDIES

13. **Evolution of a high quality strain for lac cultivation on** *palas*. Production of the high quality *Kusmi* lac in the country constitutes hardly 10 per cent of the total lac produced. This has largely been due to the limited choice of host plants for the *Kusmi* lac insects which, incidently, are also not widespread. To boost *Kusmi* lac production would, thus, require the use of a plant which is found in abundance and which can produce lac all over the country and which is otherwise of little economic value. These requirements are met by *palas* which is already the major host for *Rangeeni* lac except that it does not take kindly to *Kusmi* lac insects. Earlier attempts to grow *Kusmi* lac on *palas* had invariably failed.

The present approach to utilise *palas* for cultivation of better quality lac involves investigation of the possibility of evolving a strain from the existing *Kusmi* lac insects which could normally thrive on *palas* and yet produce high quality resin. For

TABLE IX. FINDING OUT ALTERNATE HOSTS FOR *Kusmi* STRAIN OF LAC INSECTS

Set	Species of host	Crop	Brood history	Lac sticks: Brood used (kg)	Lac sticks: Brood yield (kg)	Lac sticks: Total yield (kg)	Lac sticks: Brood to yield ratio	Sticklac (scraped lac): Brood used (kg)	Sticklac (scraped lac): Total yield (kg)	Sticklac (scraped lac): Brood to yield ratio	Remarks
Set I	*A. lucida*	*Jethwi* 1966	*Kusum* × *A. lucida*	3.6	6.6	16.8	1:4.8	1.8	3.9	1:2.2	
	Sandan	*Jethwi* 1966	*Kusum* × *Sandan*	2.5	4.6	9.1	1:3.6	1.2	3.1	1:2.6	
Set II	*A. lucida*	*Aghani* 1965–66	*Kusum*(K) × *A. lucida* (A. l.)	6.5	9.7	18.2	1:2.8	2.4	4.3	1:1.8	
	Sandan	*Jethwi* 1966	A. l. (K) × A.l.	9.7	5.3	12.2	1:1.3	2.6	3.3	1:1.3	Further crop could not be raised as no brood was obtained
		Aghani 1965–66	*Kusum* × *Sandan*	6.7	×	10.5	×	2.3	2.6	1:1.1	
Set III	*Bhalia*	*Aghani* 1965–66	A. l. (K × M.m. × A.l. × M.m.) × M.m.	9.0	8.6	18.6	1:2.1	1.9	4.6	1:2.4	
	A. lucida	*Jethwi* 1966	M.m. (K × M.m. × A.l. × M.m. × A.l.) × A.l.	8.6	14.8	36.6	1:4.2	2.2	7.0	1:3.2	

this purpose, *Kusmi* lac insects were grown on *palas* in the *Jethwi* 1966 season and, as was to be expected, this resulted in large-scale mortality of the insects. However, five females, out of an estimated 5,000 did survive and three of these reproduced at the usual *Kusmi* time in the third week of July 1966. These females were used as mothers to raise subsequent generations of the insects on *palas*. The second generation has shown marked improvement in survival rate. Nineteen females, out of an estimated 800, have survived till the end of December 1966.

14. **Study of the pleiotropic effects of the yellow gene.** It has been observed that yellow lac insects produce lighter-coloured lac. This observation is of considerable practical significance since colour in lac is a serious drawback. The yellow body colour of the insect is conditioned by a recessive allele of the normal crimson colour. It is important, therefore, to know whether the lighter colour of the resin produced by yellow lac insects is the pleiotropic effect of the yellow gene in order to ascertain the desirability of introducing in suitable genetic backgrounds, particularly that of the *Kusumi* strain, for further improvements in the quality of lac produced.

The yellow and crimson insects were raised on potted *bhalia* (*M. macrophylla*) plants in the rainy season crop. The yellow females at sexual maturity were mated to crimson males. The crossed females were, however, lost later due to general mortality of host plants for reasons not known.

15. **Selection studies for improving the size in female lac insects.** These studies could not progress as the plants on which the insects were raised died.

BIOLOGICAL AND ECOLOGICAL STUDIES ON PESTS OF LAC HOSTS, LAC ENEMIES AND THEIR PARASITES

16. **Collecting of pests of lac host trees, and studies on the life history and control operations against important pests.** (On bhalia (M. macrophylla) and ghont (Zizyphus xylopyra). Life history studies of *Hypena iconicalis* Walker, *Platypeplus aprobola* Meyr. and *Dasychira mendosa* Hubn (form *fusiformis* Walk.), all pests of *M. macrophylla*, and *Euproctis fraterna* Moore a pest of *Z. xylopyra* were completed.

Laboratory rearing of *Belippa laleana* Moore could not be continued as the pest was not available in the field.

Prodenia litura Boisd, a polyphagous species has been recorded at Namkum from *bhalia* alone. Laboratory rearings have indicated that the pest would have nine generations a year under these conditions.

The pest was most active in the field from June to November at Namkum.

The incubation, larval and pupal periods were 3, 14 to 20, and 7 to 13 days respectively. The total life cycle (egg to the adult stage) was 25 to 33 days.

(b) *On other lac hosts.* Life history studies of the limacodid (Lepidoptera) and the coreid bug (Heteroptera), both pests of *palas* were continued during the year.

(i) LIMACODID: It was reported last year (*Annu. Rep.* 1965–66) that the caterpillars pupated by the last week of December, 1965 in the fourth generation. In June 1966, the fourth generation adults emerged and immediately laid eggs for the fifth generation which completed the cycle by middle of October 1966, and passed into the sixth generation. The mature larvae pupated by December 22, 1966. This phenomena also happened in the previous year.

In the field, the pest remained active from July 20 to August 10 and again from October 20 to November 26. These, in their larval instars, feed superficially on the leaves but in the later instars completely devour the leaves.

The pest overwinters in its pupal stage and passes through a long diapause during the best part of the summer. With the rise of humidity the adults emerge and remain very active for one generation and a part of the following from June to November. The total duration of the fifth generation was 90 to 95 days.

(ii) THE COREID BUG: It was reported last year that the eighth generation was on from the end of March. By May 1966, large-scale mortality occurred either in the first or second instar nymphs. However, a few adults of the seventh generation had not mated and had not laid eggs. Therefore, eight generation eggs were available from these tail-ender adults in early September 1966, which developed and passed through eighth, ninth and tenth generations in quick succession by the first week of January 1967. Their egg stage and nymphal and development periods were as follows:

Generation	Egg stage days	Nymphal period (1–5 instars) days	Development period days
8	6–7	37–38	44–45
9	6–8	36–37	42–46
10	7–8	46–47	53–56

The pest was found to be most active during the rainy season, less in winter and least in summer. The nymphs feed by sucking the juice of succulent leaves and shoots and remain on the under surface of the leaves out of sight. During the rains, these insects were found on almost all the *palas* trees.

17. **Survey of lac enemies and their parasites**. The survey conducted is described below.

GENERAL SURVEY—QUALITATIVE: For a survey of the inimical insects associated with lac and lac insects in various lac crops raised on different hosts, the studies were continued according to the plans reported last year (*Annu. Rep.* 1965–66.)

It was reported that *Baisakhi* 1965–66 and *Jethwi* 1966 crops were started and that emergence was recorded from collections made from the fourth fortnight onwards from samples of *Baisakhi* lac and no emergence started from samples of *Jethwi* crop till the end of March 1966.

During the period under report, it was observed that larger numbers of *Eublemma amabilis* Moore and *Holcocera pulverea* Meyr. emerged at a steady rate till the harvesting of the *Baisakhi* crop raised on *galwang* than from the crop on *palas*. During the same period, both these predators emerged almost in equal numbers from the *Jethwi* crop on *kusum* and *bhalia* but their total numbers were less than those from *Baisakhi*. Parasites were conspicuous by their absence. A few odd numbers of beneficial insects were also found to emerge.

In July 1966, the *Aghani* and *Katki* crops were started and samples as per schedule collected and emergence noted. The *Katki* crop was harvested in October 1966, and the next *Baisakhi* 1966–67 was started on another set of the same hosts.

From the *Katki* samples of *palas* and *galwang*, equal numbers of both the predators emerged, whereas till December 1966 during the *Aghani* season larger numbers of *E. amabilis* emerged from the material obtained from *bhalia* than from *kusum*. The largest number of *H. pulverea*, however, emerged from *kusum*. The incidence of both the predators was highest from the second fortnight of September till the second fortnight of November in both the *Katki* and *Aghani* crops. During all the fortnights from April to December the largest number of parasites that emerged were the eulophid, *Tetrastichus purpereus* Cam. followed by *Parechthrodryinus clavicornis* Cam. (Encyrtidae). Excepting *Bracon greeni* Ashm. and a few *Pristomerus sulci* Mahd. and Kolu., no other beneficial parasite emerged during this period.

In October 1966, the subsequent *Baisakhi* crop was started.

18. **Seasonal incidence and extent of damage by predators on *Kusmi* lac grown on** *Moghania macrophylla*. To determine the incidence of the two most destructive lac predators, viz., *Eublemma amabilis* and *Holcocera pulverea*, in *Kusmi* lac grown on *bhalia*, both the *Jethwi* 1966 and *Aghani* 1966–67 crops were raised and random samples of lac collected at fortnightly intervals from the time of male emergence till maturity of the crops. These samples were microscopically examined for the presence of the predators, total population of lac insects and the number of dead ones per unit area. The results obtained in the *Aghani* 1966–67 are presented in Table X.

It will be observed that the incidence of both the predators started rising from the second fortnight of September 1966 and continued to do so till the first fortnight of December 1966. In the first two fortnights a high mortality of larvae occurred.

BIOLOGICAL CONTROL OF LAC ENEMIES

19. **Control of lac predators by the use of** *Bacillus thuringiensis* Berliner. Experiments to test the efficacy of the bacillus in the control of major lac predators, viz., *Eublemma amabilis* and *Holcocera pulverea* were continued in the *Baisakhi* 1965–66 and *Jethwi* 1965 crops, although on a limited scale due to shortage of the thuricide.

Studies during the *Baisakhi* 1965–66 were unsuccessful because all the insects including those under control died immature presumably due to the prolonged drought conditions during the summer.

In the *Jethwi* 1966 crop, thuricide in 0.03 per cent concentration was sprayed at weekly and fortnightly intervals and the treated crops compared with another receiving no application of the thuricide for yield as well as the presence of enemy and friendly insects of lac. About 500 g of harvested lac from each of the treatments were also caged for noting the emergence, later, of enemy and friendly insects.

Significant increases in the yield were obtained with the use of the thuricide, weekly sprayings giving the best yields. The data of insect emergence also showed that the crops treated with the thuricide were practically free of the predators,

TABLE X. INCIDENCE OF *E. amabilis* AND *H. pulverea* ON *Kusmi* STRAIN OF LAC GROWN ON *M. macrophylla*
Crop *Aghani* 1966–67

Sl. No.	Date of collection	Length of stick examined (cm)	Average circumference (cm)	Area examined (sq. cm)	Population of lac insects			Population of predators				Area damaged by the predators (sq.cm)	Percentage of damage	No. of dead and damaged insects per sq.cm
					Living	Dead	Total	*E. amabilis*		*H. pulverea*				
								Eggs	Larvae	Eggs	Larvae			
1.	17.8.1966	250	2.092	523.00	52,152	874	33,026	4	2	8	1	31.25	2.646	Initial
2.	2.9.1966	250	2.95	737.50	31,500	1331	32,831	10	1	2	3	32.102	4.054	mortalits
3.	17.9.1966	250	2.53	632.50	26,231	179	26,410	16	3	12	9	36.1	0.677	0.28
4.	1.10.1966	250	2.628	657.00	25,629	989	26,618	13	5	1	2	42.01	3.715	1.50
5.	18.10.1966	250	2.893	698.32	20,956	112	21,068	5	16	—	1	52.1	0.531	0.16
6.	1.11.1966	250	2.015	503.75	9,210	506	9,716	3	10	2	1	72.02	5.207	1.00
7.	16.11.1966	250	2.02	505.00	10,239	586	10,825	—	18	5	8	69.15	5.413	1.16
8.	3.12.1966	250	2.56	588.80	9,371	647	10,018	—	20	—	11	93.59	6.448	1.10
9.	15.12.1966	250	2.322	580.50	5,120	883	6,003	—	15	—	13	85.3	14.709	1.52
10.	2.1.1967	250	2.013	503.25	1,013	143	1,156	1	11	2	3	76.19	12.370	0.28

E. amabilis and *H. pulverea*, while friendly insects emerged in equal numbers from both treated and control samples.

Fresh supplies of thuricide having been received, three concentrations, i.e., 0.02, 0.03 and 0.04 per cent and no spray as control were tried in the *Katki* 1966 crop, each of which was sprayed at intervals of one, two, three and four weeks with 12 lac-bearing *bhalia* bushes under each case on a randomised block design.

The crop results confirmed the early observations of a high degree of effectiveness of the bacillus in the control of *E. amabilis* and *H. pulverea*. Increases in yield over control were 21–57, 21–89.7 and 21 per cent with 0.02, 0.03 and 0.04 per cent concentrations respectively. Differences in concentrations were not of much consequence but spray intervals were. Weekly sprayings invariably produced the best results for all the concentrations tried.

The study is being continued for the *Aghani* 1966–67 crop also.

20. **Survey of pathogenic organisms in the lac insect predators** ***E. amabilis*** **and** ***H. pulverea*****.**

The problem was taken up with the initiation of a survey of the immature stages of the two predators to find out whether pathogenic organisms are harboured by them, so that some of these could be employed towards controlling the predators.

The work was started in the middle of the year with collection of material and examination of signs of disease or abnormality. Careful pre- and post-mortem examinations were carried out of the material collected in living condition but were suspected to be harbouring/affected by unknown diseases. The material examined is given in Table XI.

TABLE XI. INCIDENCE OF DISEASED LARVAE OF *E. amabilis* AND *H. pulverea*.

Collection	*E. amabilis*				*H. pulverea*			
	Healthy	Diseased	Total	% of diseased larvae	Healthy	Diseased	Total collection	%of diseased larvae
July–Sept.	244	33	277	11.9	308	25	333	7.5
Oct.–Dec.	171	16	187	8.5	193	19	212	8.9
Toal	415	49	464	10.5	501	44	—545	8.07

Preliminary examinations revealed that both the predators in their larval stages (in unhealthy condition) harboured micrococci, diplococci, steptococci, staphylococci and polyhedral bodies. Symptoms were recorded and smear preparation made for further indentification.

CHEMICAL CONTROL OF LAC INSECT PARASITES AND PREDATORS

21. **Effect of different insecticidal sprays on the incidence of parasites and predators attacking** ***Kusmi*** **lac crop grown on** ***M. macro phylla*****.** About 200 bushes of *bhalia* (*M. macrophylla*) were inoculated for raising the *Jethwi* 1966 crop,

of which only 20 carried enough crop for experimental purposes. The experiment had to be conducted, therefore, on a very limited scale with only one lac-bearing bush under each treament.

About 0.4 per cent Cryolite, 0.4 per cent sodium fluosilicate and 0.4 per cent lead arsenate mixed with an equal quantity of lime and 0.25 per cent Dieldrex were tried, each with one, two, three and four sprayings during the entire crop period. Use of lead arsenate was found to produce burning effects on the foliage of the bushes.

Although the beneficial effect of the sprays is indicated, the experiment needs to be repeated on a larger scale for confirmation.

Experiments are being continued in the *Aghani* 1966–67 crop for which *bhalia* bushes were inoculated in July 1966. Sixty bushes are under experiment and spraying of the insecticides were given at intervals of 10 days beginning one month after inoculation. So far 10 sprayings have been done.

REGIONAL FIELD RESEARCH STATIONS FOR LAC
DAMOH, MADHYA PRADESH

(i) **Studies on the response of *ghont* to purning to grow lac crops and systematic cultivation of lac on this host.** The experiment was continued with the following treatments:

Katki 1966 crop

A—Pruning at the time of harvesting in November.

B—Pruning in the second week of February.

C—Pruning in the second week of May.

In the case of C, as there will be no fresh shoots for inoculation in June–July for the *Katki* crop after pruning in May, two coupes are used, one each for use in alternate years.

Baisakhi 1965–66 crop

A—Pruning in the second week of April.

B—Pruning in the third week of May.

C—Pruning in November.

The crop results show that the crop could not be successfully raised on *ghont* either in the *Baisakhi* or in *Katki* season.

Shoot measurement study, however, indicated that B treatment under *Baisakhi* crop and C treatment under *Katki* crop were more suited for growing lac. The latter is in conformity with the previous year's findings.

(ii) **Determination of optimum requirement of broodlac for crop inoculation on *ghont*.** The experiment was continued with following treatments:

A—Normal brood rate—Average 400 g per tree.

B—Double normal brood rate—Average 800 g per tree.

C—Treble normal brood rate—Average 1200 g per tree.

Poor yields were obtained under *Baisakhi* 1965–66 crop whereas *Katki* 1966 crop failed totally.

(iii) **Evolution of a suitable cultivation practice to be followed for *ghont*.**

The experiment was continued with the object of obtaining both broodlac as well as *ari* lac and reducing the cost of cultivation of lac. The following treatments were under study:

A—Pruning in April, light inoculation (average 200 g brood per tree) in October-November, no partial harvesting during June–July, complete harvesting in October–November next year.

B—Pruning in April, normal inoculation (average 400 g brood per tree) in October–November, partial harvesting in June–July and complete harvesting during October–November.

C—Pruning in April, heavy inoculation (average 800 g brood per tree) in October–November, *ari* cutting during April–May.

D—Pruning in October–November, light inoculation in October–November (average 200 g brood per tree), next year; no partial harvesting in June–July, complete harvesting during the following October–November. Thereafter harvesting will also serve as pruning.

E—Pruning in October–November, light inoculation in October–November, partial harvesting in June–July, complete harvesting during following October–November. Thereafter this harvesting will also serve as pruning.

Each treatment was tried on five trees with 10 replications. Each treatment had two coupes for use in alternate years. Thus there are 500 trees under this experiment.

The crop has been a failure under all the treatments.

(iv) **Permanent field experiment for working out economics of cultivation of *Kusmi* and *Rangeeni* lac on *Moghania macrophylla* under different conditions of manuring and irrigation.** *Moghania macrophylla* could not be raised on plantation scale and hence the trials remained suspended.

(v) (a) **Investigation of likely *Rangeeni* hosts occurring in the region and their proper use to supplement production of *ghont* lac.** *Baisakhi* 1965–66 as well as *Katki* 1966 crops were successfully raised only on *palas* but they failed on *airma*, *renja*, *dhoben*, *bansa*, *khair* and *sandan*.

(b) **Selection and introduction of suitable regional or exotic hosts to fortify cultivation of lac on *ghont*.** Among the exotic hosts, *A. lucida* and *S. saman* are developing satisfactorily. *M. macrophylla*, however, could not be raised.

MIRZAPUR (UTTAR PRADESH)

All the experiments at this station are being carried out on the same lines as at Damoh.

(i) **Studies on the response of *ghont* to pruning to grow lac crops and systematic cultivation of lac on this host.** Both the *Baisakhi* 1965–66 and *Katki* 1966 crops failed. The data on shoot measurement indicate that treatment A gave better response to pruning than B and C in the *Baisakhi* season which is not in conformity with the last year's findings. In *Katki* period, however, C treatment gave better response than the others confirming the previous year's findings.

(ii) **Determination of the optimum requirement of broodlac for crop inoculation on *ghont* and *palas*.** *Baisakhi* 1965–66 crop on *palas* did not give any yield of broodlac. In so far as yield of sticklac is concerned, treatment A gave comparatively better results. *Katki* 1966 crop on *palas* and both *Basiakhi* 1965–66 and *Katki* 1966 crops on *ghont* completely failed.

(iii) **Evolution of a cultivation practice to be followed for *ghont* and *palas*.** *Baisakhi* 1965–66 crop completely failed on both *ghont* and *palas*. *Baisakhi-cum-Katki* 1965–66 crops on *palas* as well as *ghont* did not yield any broodlac. Only meagre quantities of sticklac were obtained under various treatments on *ghont* whereas in *palas* so far as yields of sticklac are concerned, treatment B has given better results.

(iv) **Permanent field experiment for working out economics of cultivation of *Kusmi* and *Rangeeni* lac on *Moghania macrophylla* under different conditions of manuring and irrigation.** It has been laid out on a 1.6 hectare plot. Due to lack of irrigation facilities in the vicinity of the area, attempts have failed to grow the bushes.

(v) **Investigation of likely *Rangeeni* hosts occurring in the region and their proper use to supplement production of *ghont* lac.** In the *Baisakhi* 1965–66 as well as *Katki* 1966 crops, a very small quantity of lac was obtained on *dudhi* and *kuchai* whereas *katmouli*, *karonda*, *amaltas* failed to produce any crop. More hosts together with the minor lac hosts have again been tried for the *Baishkhi* 1966–67 crop and among them are *pipal*, *bargad*, *gular*, *rev*, *makai*, *dudhi* and *kuchai*.

(vi) **Relative importance of enemy and friendly insects.** This study could not be taken up due to shortage of staff at the station.

UMARIA (Madhya Pradesh). In view of the shifting of the station to Dharamjaigarh in Madhya Pradesh the experiments were wound up.

23. **Plantation at Namkum**. The general upkeep of the plantation was looked after as far as possible with the available labour force.

Seedling of the usual lac hosts were raised in nursery beds for both planting in the gaps in the plantation and for use in laboratory for experiments.

M. macrophylla seeds were supplied to a limited extent to the Director, Regional Office for lac Development for distribution.

24. AD-HOC STUDIES

(i) **Study of weeds.** In the trials for raising *Moghania macrophylla* and certain conventional lac host trees under bush conditions, it was observed that a variety of weeds checked the growth of the young seedlings and also made cultivation operations difficult in the Namkum plantation. It was, therefore, decided to study the weed flora with reference to their morphological characters, distribution and intensity with a view to devise means to control them.

About 83 species covering 68 genera and 24 families were recorded during the year. These belong to both dicot and monocot groups, the former comprising 73 per cent of the plants. The families Leguminosae under dicot, and Graminae under monocot, were predominantly represented.

The grasses *Saccharum spontaneum*, *Heteropogon contortus* and *Imperata cylindrica* predominated and were the most detrimental to the growth of the young seedlings of lac hosts.

Among the unwanted undershrubs and shrubs, *Mimosa pudica*, *Sida acuta*, *Clerodendron infortunatum*, *Stachytarpheta indica* and *Ageratum conyzoides* were the most commonly found and were gregarious in habit. Of these, the most harmful was *Stachytarpheta indica*.

The climbers and twiners like *Passiflora foetida*, *Quamoclit pinnata* and *Ichnocarpus fruitiscens* covered the young seedlings of the lac hosts and made them unsuitable for lac cultivation.

(ii) **Studies on the effects of herbicides on the weeds.** Stam F-34, Tok E-25, Atrazine, Varitox and Spontox were applied as post-emergence treatment in August 1966 of which Spontox and Varitox were effective against herbs and undershrubs and Stam F-34 against grasses.

RESEARCHES CONTEMPLATED

Under this head, about a dozen problems were listed last year (*Annu. Rep.* 1965–66)which were contemplated to be taken up during 1966 in addition to continuing the work in progress. These could not be taken up, except two, since there was no improvement in the staff position.

For the coming year the above are proposed to be taken up in addition to the work already in progress, should the staff position improve. In addition, with the conclusion of certain experiment on *ber* at Namkum and with the availability of hosts, it is intended to take up also studies on the relative merits of *ber* and *palas* broodlac for which necessary preparations have already been made, and inoculations, etc., will be made from October 1967.

B. CHEMISTRY DIVISION

The research activities of the Chemistry Division closely followed the pattern set out for it by the recent (1966) Achievement Audit Committee in the revised research programme they recommended for the Division. The investigations covered all aspects concerning processing, standardization and utilization of lac and its by-products as well as fundamental studies. No research staff could be recruited during the period and, consequently, the staff position continued to be difficult as before. As a result, some of the items in the programme recommended could not be taken up for study. No item of special equipment, so eagerly looked forward, were also received due to non-availability in the local market and difficulties of foreign exchange. Despite these handicaps, the research tempo continued to be as high as possible.

While progress has been maintained in general, certain findings are of particular interest and noteworthy. Among these are the two water-based red oxide primers developed by this Insitute which have already received appreciation of major consumers. It has been possible to improve the corrosion resistance of one of these, still further, by the incorporation of one per cent of *n*-butylamine. While both the primers so far developed involved the use of at least one imported material, a new formula was worked out during the period under report, based entirely on indigenous raw materials which shows promise of being just as good. Another finding of considerable potential is the improvement brought about by ethylene glycol modified shellac on incorporation in synthetic (styrene/butadiene) rubber. This modified shellac serves both as a processing aid as well as for improving the desirable properties of the rubber such as modulus, tensile strength, tear resistance, hardness, etc. Incorporation of shellac into castor oil and modification of the product with toluene diisocyanate is another finding of considerable importance in that the resulting films not only showed considerable improvement in properties over those of the parent shellac but even resisted the action of dilute caustic soda, a feature so unusual with shellac containing compositions. The preliminary results of the copolymerisation of shellac allyl ether/ester with vinyl monomers in the cold is of special interest as a possible prelude to the formulation of solventless coatings containing shellac, a field in which shellac has not found use so far.

A detailed report on the results of all the investigations now follows. The various items are listed in the same order in which they are given in the programme recommended by the (1966) Achievement Audit Committee.

1. STUDY OF CONSTITUTION OF LAC

(i) **Separation and study of the neutral fraction.** A neutral fraction had been isolated from lac resin from one of the fractions obtained by temperature phase separation of its acetone solution. An easier method for the isolation of this neutral fraction (from *palas* seedlac), its hydrolysis, separation of the non-acidic portions and conversion of the constituent acids into methyl esters, fractionation of the methyl esters into ether soluble and insoluble portions and refractionation of the ether soluble portion leading to the isolation and identification of methyl aleuritate have been described already in the earlier Annual Reports (*Annu. Rep.* 1964–65, 1965–66).

The fractions (S_1 to S_9), obtained from the ether soluble portion (E_3) of the methyl esters, were further examined during the period under report by thin layer chromatography (TLC). Fractions S_8 and S_9 (together 7.29 g) were found mainly to consist of methyl aleuritate and, so far, pure methyl aleuritate could be isolated from these to the extent of nearly 3.9 g. Each of the other fractions (S_1 to S_7) were found to contain a minor amount of methyl aleuritate. Non-hydroxy esters were present in fractions S_1 to S_5, and mid-hydroxy and di-hydroxy esters in S_6 and S_7. The presence of a few more unidentified esters was also noticed.

The non-acidic portion (E_1; 2.08 g), as already pointed out in the previous report, might, it was considered, be a mixture of hydrocarbons and alcohols. TLC examination showed it to be composed of a number of components. It was then fractionated over alumina using petroleum ether (40–60°C), chloroform and methanol into three fractions amounting to 0.46, 1.15 and 0.46 g respectively.

The first fraction gave a single spot on a TLC plate and appeared to consist of pure hydrocarbons which was confirmed by the IR spectrum. Gas liquid chromatography showed it to be a mixture having two major hydrocarbons. The second fraction gave five spots of which one was major. The third fraction did not show any clear spots.

(ii) **Soft resin.** The hydrolysis of fresh soft resin, conversion of the liberated acids into methyl esters and fractionation of the ester mixture with urea have been described already in the previous report (*Annu. Rep.* 1965–66).

The TLC examination of these methyl esters, separated with urea into adducted (A) and non-adducted (B) fractions showed that non- and mono-hydroxy esters were more concentrated in the fraction (A). (A) was then acetylated and again fractionated by urea into adducted (A.1) and non-adducted (A.2) fractions.

The acetylated adduct (A.1) was further fractionated over silver nitrate impregnated silicic acid into seven fractions (A. 1.1, A. 1.2,...A. 1.7), which were examined by TLC. A.1.1 and A. 1.3 were found to be pure indicating that these are non-hydroxy and *w*-acetoxy esters respectively. A. 1.3 was a solid and on saponification yielded an acid, m.p. 86°–87°C, which had acid value 200 and hydroxyl value 194. This indicated that the acid is monohydroxy. Infra-red result also indicated that it is a hydroxy fatty acid.

The non-adducted fraction (B) was refractionated over neutral alumina column, with benzene, ether and methanol, into nine fractions (B. 1., B. 2...B.9). Fractions B. 5., B. 6 and B. 7 were found to be mainly methyl aleuritate. After recrystalization, they melted at 70.5°–71°C and had the same Rf value as authentic methyl aleuritate.

B.1 and B.2 totalled nearly 64 per cent and TLC showed the presence of some non-hydroxy and mono-hydroxy components in both. These were mixed (C) and fractionated further into urea adducted (C1) and non-adducted (C2) fractions. C1 was acetylated and the acetylated product was found to be almost pure acetoxy butolate with traces of a non-hydroxy component which was removed by refractionations over silicic acid to give pure acetoxy butolate.

(iii) **Isolation and identification of the free acids present in shellac.** It has been reported earlier (*Annu. Rep.* 1965–66) that the mixture of free acids present in lac resin has been isolated by repeated extractions of an alcoholic solution of dewaxed decolourised lac with hexane. The mixture was fractionated into urea adducted and non-adducted fractions and examined by TLC.

The non-hydroxy acidic portion from the adducted fraction was separated from hydroxy ones by repeated chromatography over silicic acid. The hydroxy acids were then subjected to further chromatographic fractionations and, ultimately fractions containing mainly mono-hydroxy acids together with some other acid, whose polarity was between non- and mono-hydroxy acids, were obtained.

Attempts were also made to isolate the individual acids from the non-adducted portion but pure fractions could not be obtained. As it is known that esters can be resolved easily, the non-adducted fraction was converted to methyl esters. A part of the ester mixture was soluble in petroleum ether (b. p. 40°–60°) while the rest in ether. The TLC examination of these showed that the petroleum ether soluble fraction was a mixture of a number of constituents including even non-hydroxy ester, the major being 6-hydroxy and *w*-hydroxy esters. The ether soluble fraction, on the other hand, was a mixture of a lesser number of constituents, *w*-hydroxy ester being the major one with traces of dihydroxy and trihydroxy esters. Refractionation of these through urea adductation is in progress.

It will be evident from above that urea fractionation of the free acids has not given good separation of the non- and mono-hydroxy acids from polyhydroxy acids and that the esterified product holds out better promise.

(iv) **Esterification of lac.** Lac contains both free carboxyl and hydroxyl groups and can, consequently, be esterified by both acids and alcohols. Various esters of lac have been prepared and reported from time to time and in almost every case a soft, tacky mass was obtained. No attempts, however, have ever been made to study systematically the progress and nature of the reaction taking place during the esterification. Since esters of lac are important modifications which can form the basis for the preparation of other modified products with improved properties, it was thought desirable to study the progress of esterification of lac with the help of TLC which has been and is being exhaustively used for similar studies.

A sample of dewaxed lac was dissolved in methanol containing 3 per cent hydrogen chloride and refluxed for a total period of 3.5 hours at water bath temperature. Ten samples (10 ml. each) of the reaction mixture were withdrawn at timed intervals and immediately quenched by pouring into ice cold water. The samples were made acid free by repeated washing with hot water and then dried. On TLC examination of the samples and the parent lac, it was found that while the parent lac does not move at all in the solvent system, petroleum ether (b.p. 40°–60°)/ethyl ether/methanol (48/50/2) used, the esterified samples do move in a number of spots. This shows that during this esterification, alcoholysis had, perhaps, taken place thereby breaking the resin into a number of methyl esters of its constituent acids.

The same dewaxed lac was then saponified and the liberated constituent acids converted into methyl esters. TLC examination of this ester mixture in the same solvent system gave a similar chromatogram thus providing confirmation of the above presumption.

In a similar manner, *kusmi* and *ber* seedlacs were converted into methyl esters (a) by direct esterification with methanolic hydrogen chloride and (b) *via* their constituent acids. Here also, TLC examination showed similar chromatograms for all confirming once again that alcoholysis takes place during the esterification. Further work with other catalysts at reflux and room temperatures are in progress.

2. MODIFICATION OF SHELLAC

(a) **By grafting/copolymerisation with synthetic monomers.** The grafting of methyl methacrylate on hydroperoxidised lac and separation of the product into portions soluble in alcohol (unmodified lac) and toluene (the homo-polymer), and collection of the insoluble residue (presumably the co-polymer) has already been mentioned in the previous Annual Report (*Annu. Rep.* 1965–66). This insoluble material was examined during the period under report. It had a hydroxyl value of 25.16 and an acid value of 3.39. As these could not have come from the monomer or its polymer, the presence of lac in it is definitely indicated. As it was soluble neither in alcohol nor in toluene, it should be presumed to be a copolymer and not a mixture of the two resins. Further, as mentioned already, shellac graft co-polymerised with 60 per cent of its weight of ethyl acrylate produces films of superior properties. Similar films were now made from a blend of an emulsion of a homopolymer of the vinyl monomer and an aqueous ammonical solution of dewaxed lac, both in the same proportions as used for the copolymerisation. The properties of both these sets of films were totally different thus providing further proof for the graft copolymerisation.

A paper embracing the above findings was submitted and has been published in the *Indian Journal of Technology* during the period under report.

The study was further extended to mixtures of the monomers with acrylamide. To hydroperoxidised lac, mixture of ethyl acrylate and acrylamide, styrene and acrylamide were grafted under the conditions already standardised and published. Film properties of the resulting emulsions were then studied without and with curing agents, viz., formaldehyde, paraformaldehyde and hexa.

It was found that addition of formaldehyde resulted in the precipitation of the emulsion. With paraformaldehyde, although there was no precipitation, there was no curing action. With hexa, however, there was curing. The optimum proportion of hexa for this purpose was one mol of formaldehyde per mol of acrylamide and the improvement as most marked in the copolymers containing the mixture of ethyl acrylate and acrylamide in the proportion 50 and 10 per cent respectively on the weight of lac.

A paper embodying the above results has been compiled and is being sent for publication.

(b) **Modification by admixture and/or reaction with synthetic polymers and other resins.** The items studied are modification of shellac with polyesters, maleic resin and melamine—and urea resins as well as with castor oil and polyisocyanates. As, however, the results pertain more appropriately to item 14 entitled "use of lac and modified lacs in surface coatings" below, they are being reported under that head.

3. IMPROVEMENT IN THE MANUFACTURE OF SEEDLAC AND SHELLAC

(i) **Fractionation of shellac by aqueous electrolytes.** As is well known, lac resin is a solid solution of several inter- and intra-esters of hydroxy carboxylic acids. Obviously, the different constituents will have different melting and softening points and molecular weights. Attempts were made to see if it would be possible to effect a fractionation of these constituents by selective precipitation of an alcoholic solution of the resin (in which it is completely soluble) by the addition of aqueous solutions of electrolytes. It had been established that there was selective precipitation by the addition of 1 per cent aqueous sodium chloride to a 10 per cent (w/w) solution of the resin in alcohol. Several fractions had been obtained as mentioned earlier (*Annu. Rep.* 1965–66).

The various fractions were examined during the period under report for their physico-chemical properties such as melting point, colour, acid value and ether soluble and insoluble fraction contents. It was seen that although the amount of precipitate progressively increased with increasing proportions of the electrolyte solution, the nature of the precipitates did not vary much.

The differences, if any, by the use of alternate electrolytes having metallic and acid radicals of different valencies, such as sodium sulphate (Na_2SO_4), sodium phosphate ($Na_3\ PO_4$), barium chloride ($BaCl_2$) and ferric chloride ($FeCl_3$), were next examined. The fractions have been collected and their yields recorded. Certain anamolous results have been obtained which are under further examination.

(ii) **Preparation of hydrolysed lac.** In a previous report (*Annu. Rep.* 1964–65), the preparation of hydrolysed lac in the simplest possible manner and in improved yield had been reported. In this method, lac was hydrolysed with alcoholic alkali and the saponified solution either neutralised with the requisite amount of 10 per cent sulphuric acid in alcohol or passed through a column of cation exchange resin.

The work was resumed during the period under report and after several repetitions, the procedure was standardised. The hydrolysed lac, recovered through acid neutralisation was obtained in an yield of 105 per cent and had acid and saponification values of 205 and 219 respectively. The sample obtained by passing through cation exchange resin had acid and saponification values of 199 and 212 respectively and the yield was 104 per cent.

The methods were then extended to lac reclaimed from *molamma* by alkali extraction. With this lac, the yield of hydrolysed lac by the first method (sulphuric acid precipitation) was 105 per cent and it had an acid value of 197 and saponification value of 212. By the second method, the corresponding values were 102 per cent, 203 and 216 respectively.

It will be noted that hydrolysed lac prepared as described above will contain all the products of hydrolysis of lac unlike the conventional 'hydrolysed lac' prepared by aqueous alkaline hydrolysis of lac and precipitation by dilute mineral acid, which will contain only the water-insoluble products of hydrolysis. As all investigations so far (except for this Institute's Indian Pat No. 82,256) has been on the latter, and as its properties and performance are almost certain to be different from those of the present sample, study has been taken up of the comparative properties of the two. Hydrolysed lac, for this purpose, was prepared from seedlac and *molamma* in aqueous medium according to the conventional method (*Annu. Rep.* 1952–53, 37). The yield was nearly 75 per cent.

(iii) **Technical preparation of aleuritic acid.** Aleuritic acid, a colourless crystalline solid, is one of the major constituent acids of lac and is believed to be present to the extent of 34–40 per cent. It is a potential raw material for various synthetic products. By conventional alkaline hydrolysis with aqueous 5N caustic soda, it is obtained to the extent of only 20 per cent.

With the object of increasing the yield, work was started last year and it was observed (*Annu. Rep.* 1965–66) that the yield could be increased to 25 per cent by carrying out the hydrolysis in presence of 5 per cent sodium sulphite.

Continuing the work further, the experiments were repeated by varying the proportion of sodium sulphite and the time when it was added. Last year's observations were confirmed that it was best to add the sulphite (5 g per 100 g of dewaxed lac) after allowing the alkaline hydrolysis to proceed for two days and that complete precipitation of sodium aleuritate occurred in about ten days from the start of the hydrolysis. The increase in yield of crude aleuritic acid was nearly 4 per cent. It was further found that when the alkaline solution was first saturated with sodium chloride and the hydrolysis conducted in presence of sodium sulphite, the yield could be increased to 5 per cent.

Evidently, a large amount of the aleuritic acid as salt was left behind in the mother liquor after separation of sodium aleuritate. In order to isolate the acid thus left, the mother liquor was treated with dilute sulphuric acid and the precipitated soft acidic mass again treated with alkali and sodium sulphite as before. But no more sodium aleuritate separated out even on standing for a fortnight.

(iv) **Recovery of wax lost during the processing of sticklac into seedlac.** It has already been reported (*Annu. Rep.* 1964–66) that the wax lost during the processing of sticklac to seedlac goes with the wash water and that it is precipitated along with the sludge when the wash water is treated with sulphuric acid. It was also reported that only 73 per cent of the wax present in the sludge could be recovered by 12 extractions with hexane in the semi-pilot plant installed for the purpose. The study was continued in order to determine conditions for more complete recovery.

A number of experiments were carried out and, as a result, it was found that the recovery could be increased to 89.5 per cent by providing some external heating arrangement round the extractor. This arrangement also helped in lowering the number of extractions from 12 to 8 for the maximum recovery so far.

(v) **Recovery of dye.** (a) The water-soluble dye present in sticklac is removed on washing the latter with water during the processing of the sticklac into seedlac. In the technique developed by this Institute for the hygienic disposal of this wash water, it is treated with sulphuric acid and allowed to settle in tanks. Most of the dye settles down along with other materials as a sludge. Filtration and drying of this sludge is a time-consuming process.

Attempts were made to minimise this time in order to make the process more practical and economical. It was found that filtration was much more rapid and easy on boiling the settled mass for five to seven minutes when the mass coagulated. The filtered mass, obtained either by the above process or by cold filtration, could be pressed through cloth in a screw press to yield hard cakes which dried within a day in the open sun.

(b) While the major portion of the dye gets precipitated along with the sludge as mentioned above, a portion is retained in the clear aqueous layer. Recovery of this dye through preparation as insoluble calcium salt and regeneration via. sodium salt and cation exchange resin has been reported last year (*Annu. Rep.* 1965–66).

Instead of converting the calcium salt of the dye to sodium salt, the calcium salt was decomposed by boiling with an equal amount of concentrated hydrochloric acid diluted with water 40 times, this quantity of the diluted acid being used in three lots. The resulting solution, on standing for 10 days, deposited crystals of the dye. The crystals were filtered, washed with ice cold water and dried.

Yield of the dye by both the methods varied between 0.23 to 0.25 per cent on the weight of sticklac washed. This dye was completely soluble in water.

4. PHYSICO-CHEMICAL STUDIES OF LAC SOLUTION

(a) Characteristics of shellac varnish in Isopropyl alcohol.

(b) Solubility of lac in various solvents and the dilution ratio of lac and nitrocellulose in different solvents and diluents.

(c) Solvent release of shellac, dewaxed lac and bleached lac films from different solvents and mixed solvents.

(d) Compatibility and film properties of lac with other resins in printing inks.

5. BLEACHING

(a) Chemical changes in the bleaching of seedlac by different methods.

(b) Working out optimum conditions for the production of bleached lac.

6. STUDY ON POLYMERISATION AND DEPOLYMERISATION OF LAC

These items could not be taken up for investigation due to shortage of staff.

7. STUDY OF THE REACTION OF UREA AND OTHER SIMILAR CHEMICALS WITH SHELLAC

Urea, as is well known, is one of the most efficient and cheapest accelerators for shellac. When lac is heated with limited proportions of urea, the life under heat falls rapidly. When, however, it is heated with a third or more of its weight of urea, lac forms a permanently thermoplastic material. However, the melting and softening points of this material as well as its resistance to water falls rapidly with increasing duration of the heating. These results and experiments on the esterification of the product with fatty acids, etc., have already been described, in detail, in the previous report (*Annu. Rep.* 1965–66).

The possibility of improvement of the product in these respects was further investigated. First, the product obtained by heating three parts of shellac and one part of urea at 165°C for 20 hours was dissolved in alcohol and treated with powdered para-formaldehyde in the ratio of 1 and 2 molar proportions of formaldehyde per mol of urea; 0.5 per cent of hexa was used as the catalyst and the mixture was boiled under reflux for 4 hours. It was found that a clear solution was obtained which produced clean, homogeneous and glossy films of good flexibility but of almost the same properties as the parent lac in regard to water resistance and scratch hardness.

As mentioned above, the melting point and water resistance were lowered with increased duration of the heating. Obviously, the product with the requisite minimum period of heating would have the highest melting point and best water resistance. Experiments were, therefore, taken up to prepare the product by carrying on the heating for the minimum period till a homogeneous melt completely soluble in alcohol was obtained. It was found that when such a product was stirred with water to remove the water solubles (unreacted urea or its products of the heating), a major portion remained as a granular powder whereas part of it went into the aqueous layer in colloidal form. This colloidal solution filtered with great difficulty and, therefore, had to be separated from the granular material by decantation. The granular material was washed two to three times more by decantation and then dried. The combined colloidal extracts did not deposit any precipitate on treating with electrolytes, but a precipitate readily separated on treatment with dilute mineral acid. This precipitate was then filtered, washed free from acid and separately dried. The properties of the two fractions were examined.

It was found that with increasing duration of time, the material that went into colloidal solution in water progressively decreased. It also had a slightly lower melting point than the material which did not go into colloidal solution in water. Both these materials were completely soluble in alcohol and formed clear, glossy, adherent films of good hardness and elasticity. Their blush resistance under immersion in water was also somewhat superior to that of the parent lac. A systematic study of these two products separately as well as co-precipitated and their modifications are in progress.

8. ANALYTICAL METHODS

(a) Improvements in the analytical methods of lac and problems connected with grade-*cum*-specifications.

(b) Relationship, if any, between life and flow of shellac and variation of these factors under different conditions of humidity.

(c) Age of seedlac.

These could not be taken up due to shortage of staff.

Correlation of specific heat with age of seedlac. As is well known, lac is a resin which deteriorates slowly but steadily on storage. The deterioration is even more rapid if the storage conditions are improper. There is no scientific method yet to assess the age or state of deterioration of lac during storage.

Specific heat has been found to be one of the constants that also changes with the freshness of the lac, falling with progressive storage period or deterioration otherwise. This property was sought to be made use of for determining the age (period of storage) of lac. Fresh sticklacs of known hosts were obtained from different sources and processed into seedlac in this Institute, by working with water only. These were stored in the laboratory in July, 1964 and their specific heats were determined from time to time. It was found (*Annu. Rep.* 1965–66) that a drop of 7.7 to 10 per cent in the specific heats had taken place on storage of about 18 months.

These samples were further examined at the end of 24 and 30 months storage. The values had not changed appreciably from the figures obtained after 18 months storage.

9. AQUEOUS LAC VARNISH

Water-thinned red oxide primers. (i) In the previous *Annual Reports* (1963–64, 1964–65) mention had been made of an aqueous lac linseed oil varnish produced from dewaxed lac and maleinised linseed oil and used as vehicle for a red oxide anticorrosive primer of the baking type. Films of this primer on mild steel, baked at 150°C for 30 minutes had been shown to possess excellent adhesion and elasticity and to withstand exposure in the humidity cabinet quite satisfactorily. Experiments were continued to further improve, if possible, the properties of this primer. The effect of incorporation of corrosion inhibiting chemicals was investigated. Potassium chromate, sodium chromate, sodium nitrite, sodium benzoate and *n*-butylamine were tried with the following primer.

Aqueous lac-maleinised linseed oil varnish (23 per cent solids containing 60 parts lac and 40 parts maleinised linseed oil)	1,000 parts
Red oxide	180 ,,
Talc	10 ,,
Mica powder	10 ,,
Zinc oxide	5 ,,
Corrosion inhibiting chemical:	
(a) Organic	1 ,,
or	
(b) Inorganic	10 ,,

The ingredients were ball-milled for 14 hours, filtered through muslin and stored in tin plate containers.

The primer was applied on mild steel panels by dipping, brushing and spraying. After 10 to 15 minutes air drying (flash off period) these were baked at 150°C for 30 minutes and tested after 24 hours of the baking.

Of the chemicals thus tested, the primer with sodium nitrite was the best as far as scratch hardness (2 kg) was concerned.

The primer with *n*-butylamine, however, gave the best overall performance.

As regards shelf life, there has been no change in the condition of the primer and particulraly, no caking after six months storage so far.

Further work with other chemicals is in progress.

(ii) The above primer as well as another water-thinned red oxide primer based on shellac and self dispersing alkyds developed by this Institute involve the use of at least one imported material in each. The possibility of developing of a composition based entirely on indigenous materials was also investigated.

It had earlier been found (Sankaranarayanan, *Tech. Note No.* **8**) that a composition based on lac, linseed oil fatty acid, glycerol and ammonia in the proportion of 100:30:20:8 was useful as a coating material for black iron sheets. It has now been found that a slightly modified version of this formula could serve as a satisfactory vehicle for the production of red oxide primers also. The new composition was pepared by cooking shellac (100 g), linseed oil fatty acid (40 g) and glycerine (20 g), at 160°C for 1.5 hours, dissolving the product in methylated spirit (75 ml) and then in 358 ml ammonical water (containing 8 ml of ammonia of specific gravity 0.88). The primer was produced by grinding this vehicle in a ball mill for 20 hours with red oxide of iron, fine mica dust and talcum powder to a pigment volume concentration of 35 per cent. Addition of a further 250 g of water per kg of vehicle gave better grinding. The viscosity of the resulting primer was 30 seconds in a B4 Ford cup.

This primer could be applied by all conventional methods, viz., brushing, spraying and dipping. It dried readily in the air or on baking to a good matt finish. The air-dried and baked films on mild steel (baked at 150°C for 30 minutes after a flash off period of about 10 minutes) showed excellent scratch hardness, impact and corrosion resistance. Both had good adhesion to finishing coats also. Finish coat could be applied on the primed surface immediately after baking or 24 hours after air drying.

Shelf life of this primer is also good. There has been no increase in viscosity on storage in a tin plate container up to 6 months, so far. The dried films were also found to be unaffected by white spirit, kerosene, toluene, petrol and water after seven days continuous immersion. In regard to methylated spirit, a blush was observed after seven days immersion which, however, disappeared completely on air drying.

10. USE OF SHELLAC IN LEATHER INDUSTRY

This item is being investigated at the Central Leather Research Institute, Madras, as a "Scheme".

11. ADHESION OF LAC AND MODIFIED LACS

This has not been taken up for investigation due to shortage of staff.

12. RUBBER SHELLAC COMBINATIONS

(i) **Shellac or epoxy resin modified lac and styrene-butadiene rubber (1502).** Last year, it was reported (*Annu. Rep.* 1965–66) that incorporation of shellac or epoxy resin modified lac in styrene-butadiene rubber (1502) improves most of the desirable properties of the rubber. The accelerator used was

MBT (mercaptobenzthiazole). This year, the incorporation was repeated using another accelerator which is very efficient and widely used in the industry, namely, CBS (cyclohexyl benzthiazyl sulphenamide). The results are summarized in Table XI.

TABLE XI. EFFECT OF INCORPORATION OF SHELLAC OR EPOXY RESIN MODIFIED LAC ON THE RESULTANT RROPERTIES OF SBR GUM STOCK USING CBS AS THE ACCELERATOR

Base Mix: SBR (1502) 100, zinc oxide 4, sulphur 2, stearic acid 1, CBS 1.5, PBN 1, plus the following:									
Shellac	0	5	10	15	20				
Epoxy resin modified lac	—	—	—	—	—	5	10	15	20
Optimum cure at 140°C, minutes	40	40	40	40	40	40	40	40	40
Physical Properties:									
Mooney viscosity (ML4 at 120°C)	28	27	24	21	19.5	27	26	25	28
Scorch time, minutes	81	43	38	33	29	47'— 30	42	36	30
Modulus at 200 per cent kg/cm²	16.4	17.8	21.0	18.8	16.4	17.7	20.8	19.6	19.0
Ultimate elongation, per cent	250	350	400	455	510	300	350	470	600
Tensile strength, kg/cm²	16.9	24.4	26.9	25.2	22.1	24.8	29.7	29.4	29.0
Tear resistance, kg/cm	15.4	19.0	22.1	22.5	23.2	23.0	24.6	25.0	25.3
Durometer hardness	50	52	55	57	60	53	56	59	63
Impact resilience, per cent	72.5	68.9	65.3	62.8	61.2	71.7	68.9	65.3	61.2
Abrasion loss, ml/1000 revs.	3.0	3.5	3.9	4.5	5.5	3.8	4.2	4.8	5.9
Immersion, weight increases, per cent									
In benzene for 96 hours at 25±1°C	307	359	384	420	460	339	351	384	423
In petroleum ether for 96 hours at 25±1°C	76	78	78	79	81	75	74	73	73

CBS has been found to be more effective than MBT and its use gives a higher modulus, tensile strength, tear resistance, hardness and impact resistance. Epoxy resin modified lac, again, has been found to behave better than plain shellac. However, the resulting adverse effects on abrasion resistance could not be offset by this change of accelerator.

(ii) **Ethylene glycol modified shellac and styrene- butadiene rubber (1502).** As mentioned above, the incorporation of shellac or its epoxy resin modification in styrene-butadiene rubber enhances most of its mechanical properties except abrasion resistance. Abrasion resistance is a very desirable property demanded in rubber goods (e.g. tyres) which come into contact with an abrasing surface.

TABLE XII. EFFECT OF INCORPORATION OF ETHYLENE GLYCOL MODIFIED SHELLAC ON THE RESULTANT PROPERTIES OF SBR GUM STOCK USING MBT AS THE ACCELERATOR

Base Mix: SBR (1502) 100, zinc oxide 4, stearic acid 1, sulphur 2, MBT 1.5, PBN 1; plus the following:

Ethylene glycol modified shellac	0	2.5	5	7.5	10
Optimum cure at 140°C, minutes	45	40	40	40	40
Physical properties:					
Mooney viscosity (ML4 at 120°C)	29	29	28	27	25
Scorch time, minutes	70′-0″	36′-30″	35′-3″	34′-7″	32′-5″
Modulus at 200 per cent, kg/cm²	9.9	13.0	12.4	12.9	13.2
Ultimate elongation, per cent	350	300	330	360	400
Tensile strength, kg/cm²	14.5	15.7	18.0	20.4	23.7
Tear resistance, kg/cm	14.0	14.4	15.0	15.2	15.2
Durometer hardness	48	50	50	51	52
Impact resilience, per cent	65.3	68.9	65.3	65.3	64.6
Abrasion loss, ml/1000 revs.	3.1	3.5	3.7	3.68	3.65

TABLE XIII. EFFECT OF INCORPORATION OF ETHYLENE GLYCOL MODIFIED SHELLAC ON THE RESULTANT PROPERTIES OF SBR GUM STOCKS USING CBS AS THE ACCELERATOR

Base Mix: SBR (1502) 100, zinc oxide 4, stearic acid 1, sulphur 2, CBS 1.5, PBN 1; plus the following:

Ethylene glycol modified shellac	0	2.5	5	7.5	10
Optimum cure at 140°C, minutes	40	40	40	40	40
Physical properties:					
Mooney viscosity (ML4 at 120°C)	28	28	27	26	24
Scorch time, minutes	81′-0″	63′-38″	50′-2″	43′-30″	36′-2″
Modulus at 200 per cent, kg/cm²	16.4	13.6	13.8	13.7	13.8
Ultimate elongation, per cent	250	240	320	330	350
Tensile strength, kg/cm²	16.9	17.2	20.9	20.8	20.9
Tear resistance, kg/cm	15.4	15.5	15.6	17.0	19.7
Durometer hardness	50	50	51	52	53
Impact resilience, per cent	72.5	68.9	68.9	67.0	65.3
Abrasion loss, ml/1000 revs.	3.2	3.58	3.6	3.63	3.68

As this loss of abrasion resistance is possibly due to the inherent brittleness of shellac, flexible modifications were tried to counter this loss.

Previous work at the London Shellac Research Bureau (*LSRB Tech. Note* **17**) had shown that shellac forms a soft sticky material on treatment with ethylene glycol which, later on, can be polymerised into a tough elastic mass. This modification was, therefore, first prepared by treating shellac with ethylene glycol at 180°–190°C using concentrated sulphuric acid as the catalyst. After the reaction, the product was thoroughly washed with boiling water to remove the acid and unreacted glycol. To drive out the moisture, the product was heated in an open pan at 110°–120°C for about 1.5 hours. The material thus obtained had an acid value of 22.0 and hydroxyl value of 200.2.

The results obtained by incorporation of this product into styrene-butadiene rubber using the two accelerators, MBT and CBS, are summarized in Tables XII and XIII.

It will be observed that ethylene glycol modified shellac, besides acting as processing aid, improves modulus, tensile strength, tear resistance and hardness of styrene-butadiene rubber. The abrasion resistance is lowered, but to a much lesser extent than with plain shellac or epoxy resin modified lac. Thus, ethylene glycol modified shellac appears to be a better compounding ingredient for styrene-butadiene rubber than plain shellac or its epoxy resin modification.

Further work with other accelerators and fillers is in progress.

13. COMBINATION OF LAC WITH OTHER RESINS, NATURAL AND/OR SYNTHETIC, FOR MOULDING WORK

(i) **With urea/formaldehyde resin.** Experiments had been carried out for the production of thermosetting moulding powders based on shellac and urea formaldehyde resin (*Annu. Rep.* 1965–66). It had been found that on increasing the proportion of urea resin in a moulding composition containing shellac and jute stick dust, the impact strength is increased. The study was continued and it was found that with the increase of urea resin above 50 per cent on the weight of shellac, flow and fusibility are adversely affected which was apparent from the unfused edges of the moulded articles.

(ii) **Butyl ester of hydrolysed lac with polyvinyl chloride.** Incorporation of butyl ester of hydrolysed lac had been found to reduce the brittleness of moulded products from polyvinyl chloride (PVC) (*Annu. Rep.* 1965–66). The colour of the mouldings was, however, very dark. In order to produce articles of lighter shade, butyl ester of hydrolysed lac prepared from bleached lac was used. It was found that the product with high proportions of the ester had poor strength. The maximum quantity of the ester which could be incorporated was 8 g per 100 g of PVC to get properly plasticised articles. However, the mould articles began to darken after two or three hours. So litharge was mixed into the composition as a stabiliser. Up to two months (so far), no change in colour of the article was noticed.

In place of the ester of hydrolysed lac, butyl ester of dewaxed decolourised lac was also tried. It was found that this also acts in the same way as the ester of hydrolysed lac. Attractive articles, yellow in colour, could be produced.

14. USE OF LAC AND MODIFIED LACS IN SURFACE COATINGS

(i) **Shellac modified with saturated and unsaturated polyesters**

Study of driers and accelerators and solvent resistance of the modified films. Polyesters are modern synthetic resins finding increasing use in surface coatings, particularly in solventless coatings. Incorporation of polyesters based on glycerol, phthalic anhydride and aliphatic saturated and unsaturated acids into alcoholic and aqueous dewaxed lac varnishes were studied and improvements in film properties obtained were reported in detail in the previous annual report (*Annu. Rep.* 1965–66).

As the air-dried films had been found to be inferior in properties to those of the baked ones, the effect of addition of drier and accelerator was investigated during the period under report. Cobalt was used as the drier. The study was naturally confined to varnish blends containing only unsaturated polyesters and, again, only to those containing dewaxed lac and the polyesters in the ratio of 3:1, as only this proportion had already been found to give the best overall performance. As cobalt

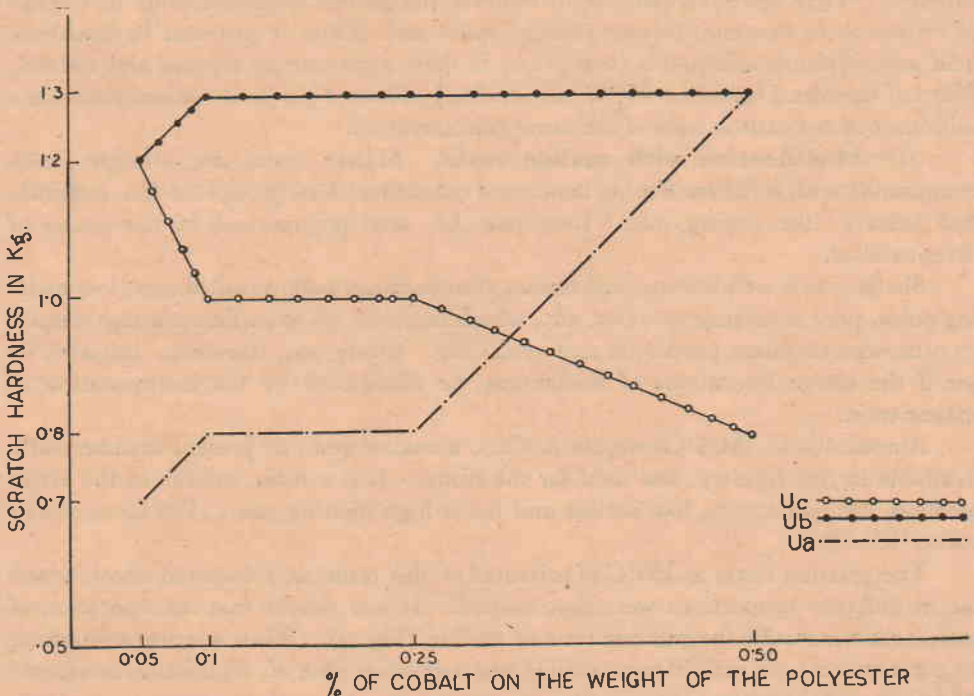

FIG. 1. Improvement in scratch hardness by the use of cobalt, 0.1 per cent of cobalt is optimum.

gets precipitated in aqueous alkaline solutions, the study had necessarily to be on spirit varnishes only.

Varnishes were prepared containing various proportions of cobalt naphthenate in toluene solution equivalent to from 0.05 to 0.5 per cent of cobalt on the polyester contents. Films were prepared on glass slides and tin panels and allowed to air dry in the laboratory for seven days before testing. It was found (Fig. 1) that scratch hardness improved by almost 50 per cent (from 0.9 to 1.3 kg) and that 0.1 per cent of cobalt was the optimum. The best performance was also given by using the polyester produced from glycerol, phthalic anhydride and maleic anhydride in the ratio of 1 :0.5 :0.5 of their equivalents. Besides this, no other marked difference such as in water resistance, etc., was noticeable.

Benzoyl peroxide was investigated as the accelerator (free radical catalyst). Here again, only spirit varnish blends containing dewaxed lac and unsaturated polyester in the ratio of 3 :1 were used. Half to 2 per cent of the accelerator did not effect any improvement. More than 2 per cent caused precipitation.

Solvent resistance. Resistance to solvents other than water of the films of dewaxed lac polyester blends, both in spirit and in aqueous medium, was then investigated. Films on tin panels, both air dried as well as baked at 100°C for one hour and 150°C for 30 minutes, were kept immersed in the respective solvents and their condition examined at the end of 1, 3, 6 and 24 hours.

It was found that the air-dried films were poor but the baked films were definitely superior. They were comparable to those of the parent unmodified lac in respect of resistance to benzene, toluene, white spirit and dilute 1 per cent hydrochloric acid and sulphuric acid and were superior in their resistance to acetone and alcohol. Films of the blend baked at 150°C also resisted dilute 2 per cent sodium carbonate solution but not caustic soda of the same concentration.

(ii) **Modification with maleic resin.** Maleic resins are straight chain compounds with sufficient double bonds and other functional groups in the molecule and behave like drying oils. They can be cold polymerised by the action of drier/catalyst.

Shellac, as is well known, has certain shortcomings such as brittleness, low melting point, poor resistance to water, etc., which limits its use in surface coatings despite its otherwise excellent properties and versatility. Study was, therefore, initiated to see if the above limitations of shellac can be eliminated by the incorporation of maleic resin.

Alresat 400 C (M/S Chowgule & Co.), a maleic resin at present commercially available in this country, was used for the study. It is a resin, soluble in the lower alcohols, ammonia, etc., like shellac and has a high melting point (128°C) and acid value (131.9).

The gelation times at 150°C of mixtures of this resin and dewaxed decolourised lac in different proportions were first studied. It was found that incorporation of maleic resin increases the gelation time of shellac (Fig. 2). Thus mixture containing 30 parts maleic resin and 70 parts shellac had a gelation time of 38 minutes as against 24 minutes of the parent lac.

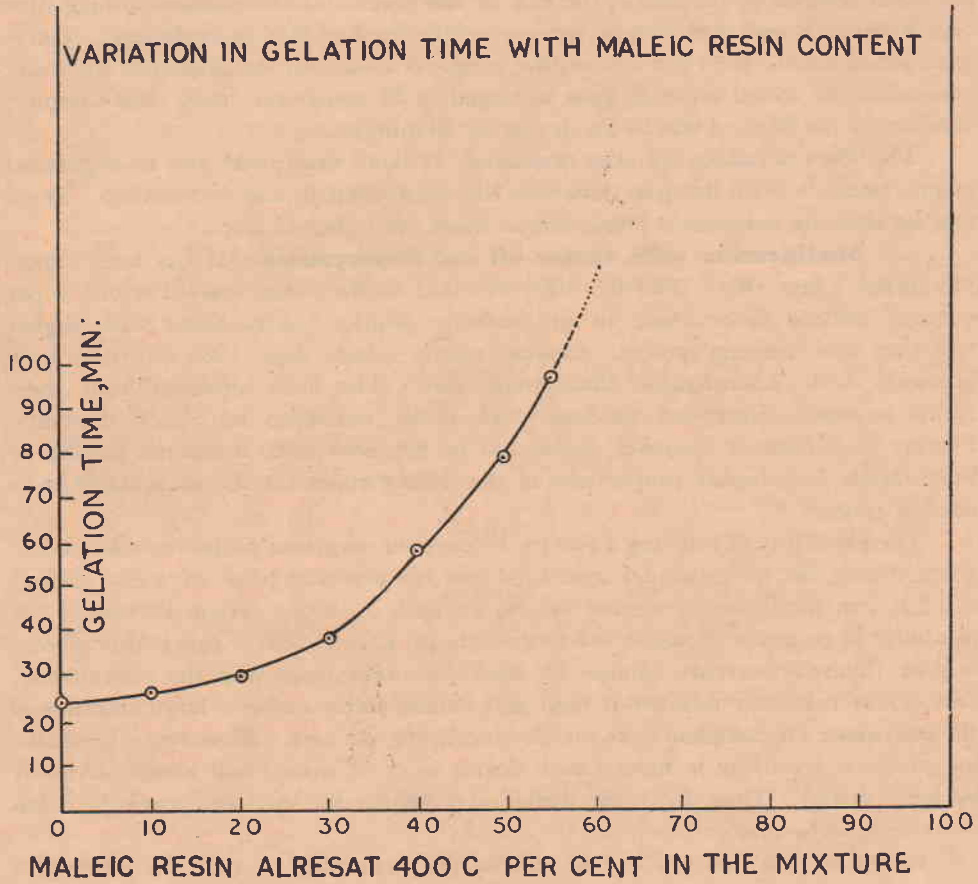

FIG. 2. Incorporation of maleic resin increases the gelation time.

The melting point of the product containing 30 parts maleic resin and 70 parts shellac and fused at 150°C for 10 minutes was 98°C whereas it was 75°C for the shellac alone and 80°C for the shellac after heating at 150°C for 10 minutes. There was no increase in the melting point of the fused mixture when stored at laboratory temperature for six months (so far).

Varnish blends of 25 per cent "solids" containing dewaxed decolourised (platina) shellac and maleic resin were prepared in which the latter constituted 10, 20, 30 and 40 per cent of the total solids. These were stored in well stoppered glass bottles and properties of the films on glass and tin panels, air dried for 7 days or baked at 150°C for 30 minutes, were studied.

It was observed that the composition containing 30 parts maleic resin and 70 parts shellac gave the best performance as far as the air-dried films are concerned. The initial blushing time of the film was 12 hours and the blushed film, after continuous immersion in water for 24 hours, completely recovered, on air drying, within one hour whereas in the case of the film of the parent lac, the initial blushing time was 30 minutes and there was no recovery of the blushed film on air drying. Incorporation of cobalt (0.03 per cent on the weight of solids) further improved the water resistance; the initial blushing time increased to 20 hours and there was complete recovery of the blushed film on air drying for 30 minutes.

The effect of baking was also examined. Without drier there was no significant improvement. With the drier, however, the improvement was astounding. There was no blush on continuous immersion in water even after 15 days.

(iii) **Modification with castor oil and diisocyanate.** It has been reported earlier (*Annu. Rep.* 1962–63, 1963–64) that shellac when reacted with 1.6 per cent of toluene diisocyanate in dry acetone solution, gives resins with higher softening and melting points. Similar results (*Annu. Rep.* 1965–66) had been obtained with naphthalene diisocyanate also. The films obtained from these resins possessed improved hardness and blush resistance but poor elasticity. Further improvement, however, could not be achieved since it was not possible to react shellac with higher proportions of the diisocyanates for use as a single pack coating system.

The possibility of evolving a two pack system of improved properties was investigated during the period under report. From the practical point of view shellac, as such, can hardly make a good vehicle for such a coating system because (*a*) its solubility in common urethane solvents, such as ketones, esters and hydrocarbons, is poor (hydroxy solvents cannot be used since they react with the isocyanates), and (*b*) its reactivity number is high and consequently requires large amounts of the isocyanate for complete cure thereby increasing the cost. Moreover, the resulting products are likely to have a high degree of cross linking and would obviously be more brittle. Thus, for using shellac as a vehicle for urethane coatings, it has necessarily to be modified.

Castor oil is a material in wide use in the preparation of urethane coatings to improve water resistance and elasticity. Castor oil can also be incorporated with shellac at about 250°C using certain metallic oxides as incorporating agents. It was, therefore, proposed to first modify shellac with castor oil and then react with the isocyanate.

Castor oil was first heated to 250°C and calcium hydroxide (4.5 per cent on the weight of shellac) added. After it had dissolved (about 10 minutes), shellac (dewaxed) was added in small lots with efficient stirring so as to avoid overflow of the material due to frothing. The temperature was maintained at 250°C (± 5°C) till a clear melt was obtained. Combinations with different shellac/castor oil ratio were thus prepared.

These shellac/castor oil combinations were found to be soluble in ketones, hydrocarbons and esters. The solubility in these solvents, however, decreased with increasing proportions of shellac. However, the products with shellac and castor oil in the ratios of up to 55 :45, dissolved freely in methyl isobutyl ketone (MIBK), toluene and butyl acetate. Acid and hydroxyl values of these combinations were determined. Since the presence of calcium radical interferes in determinng the correct end points, compositions for these determinations were prepared using sodium hydroxide as incorporating agent. Values obtained are indicated in Fig. 3.

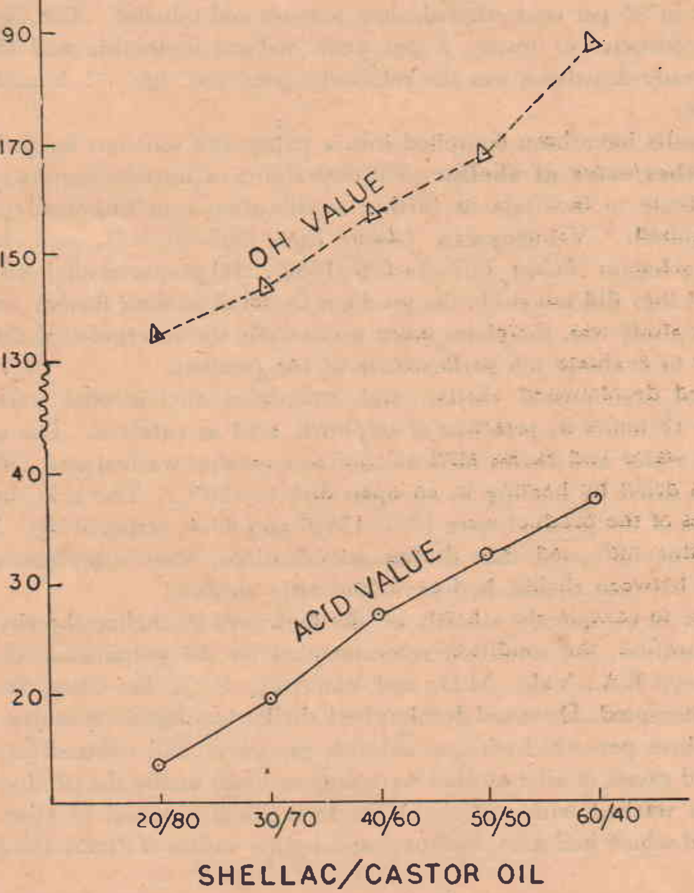

FIG. 3. Determination of the acid and hydroxyl values of shellac-castor oil combination.

Solutions of various shellac/castor oil combinations were prepared in MIBK or toluene and the required amounts of toluene diisocyanate, calculated on the basis of acid and hydroxyl values, were added and mixed thoroughly. The mixed soultions were allowed to stand at room temperature for 10 minutes, after which films were prepared on glass and tin panels. Properties of the films were examined after one week.

It was seen that films obtained from compositions containing shellac and castor oil in ratio of less than 40/60 remained soft even when allowed to air dry for seven days. The hardness of the films increased with the increased proportions of shellac.

The best results were obtained with the composition containing 55 parts of shellac blended with 45 parts of castor oil and cured with 30 parts of toluene diisocyanate. The films were hard (scratch hardness 1.6 – 1.7 kg), glossy and flexible. There was no damage to these films when rubbed hard more than 50 times with cotton pads soaked in 95 per cent ethyl alcohol, acetone and toluene. The films also possessed good resistance to water, 5 per cent sodium hydroxide and 6N sulphuric acid. The only drawback was the relatively poor pot life (1.5 hours) of the compositions.

The results have been compiled into a paper and sent out for publication.

(iv) **Allyl ether/ester of shellac.** The desirability of introducing unsaturation into shellac molecule to facilitate its further modification into improved products had been recognised. Venugopalan (*Annu. Rep.* 1949-50, 17), and Puntambekar and Venkatachalam (*Indian J. Technol.* **6** (1963), 231) prepared allyl ester of lac with this idea but they did not study the products in detail or their further modifications. A systematic study was, therefore, taken up to study the reaction of shellac with allyl alcohol and to evaluate the performance of the product.

Dewaxed decolourised shellac and anhydrous allyl alcohol were taken and refluxed for 12 hours in presence of sulphuric acid as catalyst. The material was poured into water and excess allyl alcohol and catalyst washed out. The resulting product was dried by heating in an open dish to 120°C. The acid, hydroxyl and iodine values of the product were 17.7, 136.6 and 80.6, respectively. The drop in hydroxyl value indicated that during esterifications, some etherification also had taken place between shellac hydroxyls and allyl alcohol.

In order to completely etherify all the hydroxyls of shellac thereby introducing more unsaturation, the condition recommended for the preparation of α-allyl glycoside (Talley, E.A., Vale, M.D. and Yanovsky, E. *J. Am. Chem. Soc.* **67** (1945), 2037) was attempted. Dewaxed decolourised shellac was dissolved in dry allyl alcohol containing three per cent hydrogen chloride gas (w/w) and refluxed for eight hours. The acid and excess of allyl alcohol were removed and finally the product in etherial solution was washed with water. After drying and removal of ether, a product was obtained which had acid, hydroxyl and iodine values of 21.22, 153.5 and 70-74, respectively.

The above product was dissolved in toluene and treated with equivalent amount plus a slight excess of metallic sodium and refluxed for five hours at 125°C. Allyl bromide equivalent to the sodium used was added dropwise after which the mixture was refluxed at 80°C for four hours more. Thereafter, the toluene, allyl bromide, etc., were removed by steam distillation, the residue taken in ether, washed with water and dried. Removal of ether gave a sticky product which had acid value 13, hydroxyl value 110 and iodine value 83–84.

It will be evident from the foregoing that neither of these two methods have resulted in etherification of shellac hydroxyls to a larger extent than the first one carried out in presence of sulphuric acid.

Film properties The ether/ester was a sticky balsam like material and soluble in the usual shellac solvents as well as in ether, aromatic hydrocarbons, ketones and esters but insoluble in aliphatic hydrocarbons.

Film properties were studied only from a solution of the material in alcohol or toluene. The film did neither dry in air nor on baking under the conventional schedule, viz., 100°C for one hour or 150°C for 30 minutes. But with 0.2 per cent cobalt naphthenate incorporated in toluene solution it dried in air overnight or when baked. Though the air-dried and baked films were glossy, hard and elastic, only the baked films were water resistant.

Attempts were then made to improve the material in respect of blush resistance of the air-dried films by incorporating toluene diisocyanate or additional shellac and urea. The improvement was better with the former than with the latter. The results with toluene diisocyanate are indicated below.

Modification of the ether/ester with toluene diisocyanate (Suprasec C). A 25 per cent solution of the product in MIBK or toluene was treated with different percentages of *Suprasec C*, viz., 10, 15, 20, 25 and 30 per cent by weight of the ether/ester. After thorough mixing and allowing to stand for about 10 minutes, films were prepared on glass slides and metal panels. The films dried to touch within a few hours and became hard and glossy on standing overnight. The solutions also set to a gel within a short period. The optimum proportion of the diisocyanate for best film properties was 20 per cent on the weight of the ether/ester. Films containing this proportion were hard, tough and elastic, withstood continuous immersion in water and 10 per cent sodium carbonate solution for 10 days and also 5 per cent caustic soda solution although the films lifted from glass slides after seven days. These were also resistant to 50 rubs with cotton wool soaked in toluene, acetone or alcohol. On continued immersion in these solvents, however, these films were damaged within two hours.

Preliminary experiments on pigmentation of the varnishes containing cobalt drier did not give glossy films while with 20 per cent diisocyanate, hard and excepttionlly glossy finishes completely free from brush mark were obtained.

The chemical reaction of toluene diisocyanate with shellac allyl ether/ester was also investigated. It was found (Fig. 4) that there was hardly any drop in acid indicating absence of any reaction with this group but drop in the hydroxyl value, in proportion to the amount of diisocyanate used, indicated reaction with the hydroxyl groups.

Copolymerisation with monomers. Apart from the solvents mentioned above, the allyl ether/ester was also found to be easily soluble in monomers such as styrene, ethyl acrylate, methyl methacrylate, etc. Preliminary experiments have shown that a solution in methyl methacrylate sets to a solid gel at room temperature in the presence of benzoyl peroxide indicating possibilities for use as solventless coatings.

(v) **Shellac etch primer.** This Institute had earlier developed a single pack etch primer based on dewaxed shellac, phosphoric acid and zinc chromate and the composition has been in commercial production by a leading firm of paint manufacturer in this country for the past few years. One of the limitations of this composition, viz., the specificity of the zinc chrome to be used, had been overcome by the incor-

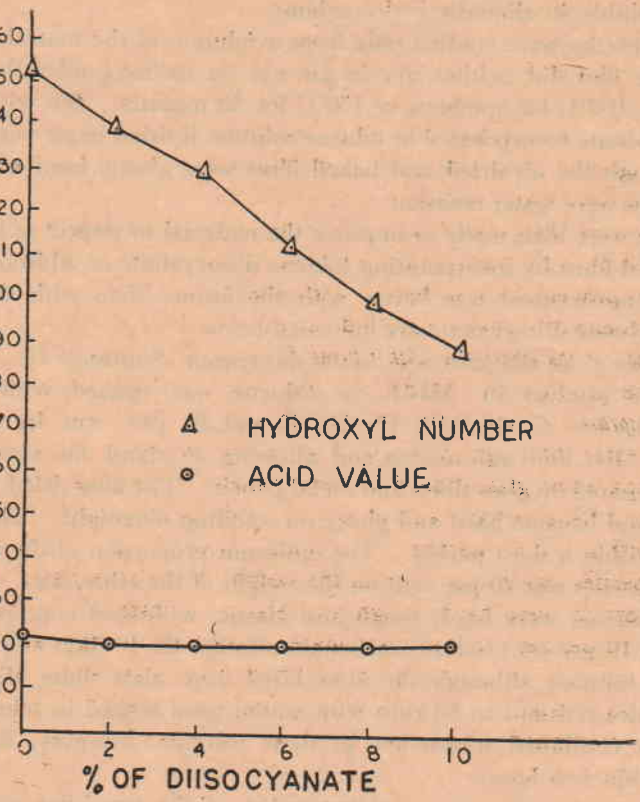

FIG. 4. Chemical reaction of toluene diisocyanate with shellac allyl ether-ester.

poration of small percentages of hydroxy acids, particularly malic acid. With the use of this acid in appropriate proportions, a signle pack etch primer was also developed using even the more alkaline and more anticorrosive and conventional pigment of etch primers, viz., zinc tetroxychromate. Aluminium and galvanised iron panels coated with this shellac/malic acid/zinc tetroxychromate primer, partly also finished with air drying alkyd enamel, had been exposed over the roof of this Institute laboratory for natural weathering. Condition of this panel had been already reported in the previous annual report as satisfactory (*Annu. Rep.* 1965–66).

After further nine months, i.e., at the end of the period under report, the condition of the primer surface on both the panels continued to be satisfactory as before. On the area where alkyd enamel had been used, the finish continued to be satisfactory on the galvanised iron panel whereas on aluminium, it started developing minute cracks about six months earlier, i.e., after weathering for nearly 8 months.

Improving corrosion resistance of steel. As mentioned in the previous Annual Report, shellac etch primer based on shellac (100), malic acid (20), zinc tetroxychromate (95) and talc (5) and solvents was found to have extraordinary adhesion and elasticity on steel. Exposure of such panels to natural weathering, however, showed that rust spot started developing quickly. An improved composition was, therefore, developed replacing part of the malic acid by an adequate quantity of phosphoric acid. Fresh panels were prepared and exposed for natural weathering and it was again found that rust spots developed in two to three months, indicating that composition required further improvement.

Import substitution. It will be noticed that all compositions developed in the Institute so far, as well as all etch primer developed any where in the world, are mostly based on zinc chrome pigments. As zinc is an imported item and other chromate pigment such as barium potassium chromate and barium chromate are produced indigenously, experiments were taken up to see whether either of these pigments could not be used in place of or at least in partial substitution of zinc chromate in our etch primer compositions.

The standard composition was prepared substituting barium potassium chromate,

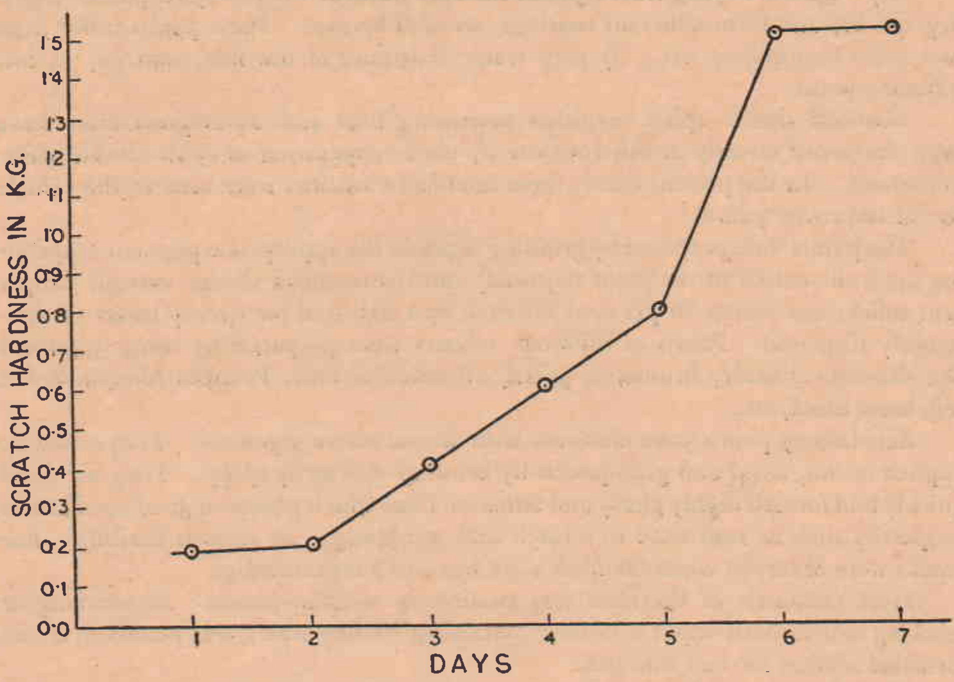

FIG. 5. Standard composition prepared with barium potassium chromate. The film needed a week to reach its maximum hardness.

weight for weight, for zinc chromate. It was found that the film (on aluminium) was extremely slow drying and needed about a week to reach its maximum hardness (Fig. 5). Even then, it had poor elasticity and readily cracked on bending the panel over a 3 mm mandrel.

Attempts were then made to see if the pigment concentration could be altered, to achieve more rapid hardening of the film. It was found that when the proportion of the pigment was reduced by half, i.e., when it was 50 per cent on the weight of shellac, the film acquired its maximum hardness within 24 hours as happens in the case of our standardised primer. This film also possessed adequate elasticity and showed no cracks on bending over the same mandrel.

A new primer of the following revised composition has, therefore, been prepared to examine its storage stability and performance.

Composition of the new primer

Shellac—100
Methylated spirit—100
Barium potassium chromate—50
Talc—5
n-Butanol—82
Phosphoric acid—30

After two months, so far, the primer is still keeping well.

(vi) **Quick drying water-proof shellac paints.** Shellac spirit paints, which dry quickly and form adherent coatings, are well known. These paints suffer from two main limitations, viz., (i) poor water resistance of the film, and (ii) its low softening point.

Modified shellac spirit varnishes producing heat and water-proof films have been developed already in this Institute by the incorporation of spirit-soluble melamine resin. In the present study, these modified varnishes were used as the vehicle for the improved paints.

The paints were prepared by grinding together the appropriate pigment (depending upon the colour of the paint required) and the modified shellac varnish (30 per cent solids) containing 10 per cent butanol, in a ball mill for twenty hours till thoroughly dispersed. Paints of different colours were prepared by using pigments like titanium dioxide, Brunswick green, ultramarine blue, Prussian blue, monolite red, lamp black, etc.

Satisfactory paints were obtained with all the above pigments. They could be applied on tin, wood and glass panels by brush as well as by spray. They air-dried quickly and formed highly glossy and adherent films which possessed good mechanical properties such as resistance to scratch and scrubbing. As regards flexibility, fine cracks were observed when the films were bent on 3 mm mandrel.

Heat resistance of the films was studied on wooden panels. No sticking or marking was noticed when a beaker containing bioling water was placed over the air-dried surface for two minutes.

Water resistance of these films was investigated by immersing the film on glass slides in water for seven days. No softening or peeling off of the film was noticed.

The films were also resistant to acids and solvents like toluene, benzene, white spirit and alcohol.

These quick-drying paints can thus be used for shop windows, display panels, etc., without fear of any damage to them through heat or water.

(vii) **Single pack acid catalysed wood lacquer.** It had already been reported (*Annu. Rep.* 1965-66) that shellac spirit varnish, modified by incorporating 20 per cent urea resin and 0.5 per cent *p*-toluene sulphonic acid (on the weight of solids), acts as a heat- and water-proof finish for wood and that this varnish possesses good shelf life. Further experiments have now shown that this composition stores well up to one year (so far studied), without gelling or any deterioration in the film properties.

(viii) **Metal lacquer.** It has already been reported that lac-urea resin varnishes produce, on metals like tin, highly flexible, glossy and adherent films which, on baking at 150°C for 30 minutes, show excellent resistance to the action of water, acids, dilute alkali and solvents including alcohol.

In view of the above, the use of this lacquer for internal coating of tin containers for packaging shellac varnish was investigated.

The containers were coated internally by slushing and baked at 150°C for 30 minutes. A hard, adherent and glossy finish was invariably obtained.

Different types of shellac and modified shellac spirit varnishes (heat- and water-proof varnish, etc.) were packed in these containers and stored. At the end of each month, they were examined for change in colour, acidity and viscosity. The coatings of the container were also examined for any damage such as softening or dissolution of the coating.

At the end of nine months (so far studied), it was found that the coating remained perfectly unaffected nor was there any change in the condition of the varnish packed, indicating thereby suitability of this coating for the packing of shellac varnish.

15. DEGRADATION PRODUCTS OF LAC

16. ELECTRICAL PROPERTIES OF LAC AND ITS MODIFICATIONS

17. (i) SHELLAC COMPOSITION FOR HYDRAULIC MODEL (ii) STRIP COATING COMPOSITIONS

These also could not be taken up due to shortage of staff.

18. **Ad-hoc Researches.** (i) *Shellac as binder for sand moulds in foundries.* Enormous quantities of resins are used as binder for sand moulds and cores in foundries. The possibility of developing shellac-based compositions for this purpose was taken up in cooperation with the laboratories of the Foundry Forge Plant of the Heavy Engineering Corporation, Ranchi. Materials and formulations were supplied from this Institute and samples produced and tested at the Foundry Forge Laboratories. As a result of this co-operative work, an aqueous composition of shellac (one part), dextrine (one part), and hydrolysed lac (0.5 part) in aqueous ammonia

had been developed which satisfied all the laboratory tests as mentioned, in the previous Annual Report (*Annu. Rep.* 1965–66).

At the suggestion of that laboratory lac-linseed oil blends formulated under a variety of conditions were investigated during the year under report. Laboratory tests (Table XIV) indicated that most of the formulae were satisfactory and particularly, the one containing dewaxed shellac (40 parts) incorporated into linseed oil (100 parts) in the presence of lime (6 parts). The Foundry Forge Plant laboratory has now desired to carry out "plant tests" for which the necessary samples (4 kg each) have been prepared and supplied. The laboratory authorities have also been requested to take up "plant trials" of the aqueous shellac compositions for replacement of imported products.

(ii) *Insulating composition for enamelling of conductors.* As a result of an enquiry, a study was taken up to try out shellac-based insulating compositions for the production of enamelled copper wires. A few compositions are already available in patent literature of which the most promising is the one based on shellac and hexamethylene adipate (nylon), in metacresol as solvent, and solvent naptha as thinner. This was tried under the standard conditions of enamelled wire manufacture, namely, dipping the conductor in the varnish, wiping off the excess through a gadget and drying the coating by baking at 300–360°C for 30 to 120 seconds. The best coating was obtained at a temperature of 300°C with a baking period of 90 seconds. However, although the films were glossy and resistant to the required solvents (*Annu. Rep.* 1965–66), the adhesion was not adequate. When the conductor was wound into a coil on itself (as required under the specification IS: 1595–1960), the film cracked. An alternate composition obtained by heating together equal parts of shellac and cashewnut shell liquid at 150–200°C for about half an hour and dissolving in a mixture of butyl alcohol and toluene was tried but this was even worse in respect of elasticity. This composition was then further modified by incorporating hydrolysed lac (20 per cent on the weight of shellac) together with an equal weight of phenol which is known to be a toughening agent for shellac. This modified composition, applied as above and baked at 270°C for 90 seconds gave better adhesion. However, it was only comparable to the product obtained with nylon; it still fell short of the actual requirement.

Yet another composition recently formulated at this Institute, namely, shellac-castor oil combination modified with toluene diisocyanate was also tried but without much success.

(iii) *Microporous separators for storage batteries.* Imported microporous separators are used in manufacture of storage batteries. The follwing study was taken up to evolve a composition to replace the imported material with indigenous ones.

Non-woven jute fabric was soaked in "melfolac" varnish (a spirit varnish containing dewaxed shellac and spirit-soluble melamine resin in the ratio of 100 :40). The soaked fabric was dried and then pressed at 800 lb at 85°C. For testing, the sample was kept immersed in dilute sulphuric acid of sp. gravity 1.25. After fifteen days immersion it became slightly brittle.

The above experiment was repeated, using an alcoholic solution of lac-cashew

TABLE XIV. REPORT OF EXPERIMENTS WITH LINSEED OIL BASED SHELLAC COMPOUNDS PREPARED AT I.L.R.I., NAMKUM

Sl. No.	Green compression	Green permeability	Dry properties	Baked at 200°C ½ hr		1 hr		1½ hr		Heated to 900°C for 1 hr	Composition of the sample supplied	
1.	Not possible	219	Compression	—13	kg/cm²	—13	kg/cm²	—13	kg/cm²	Sample is	Platina shellac	— 40 parts
			Shear	6.3	,,	10	,,			completely	Linseed oil	— 100 ,,
			Tensile	4.4	,,	6.0	,,	—10	,,	collapsible	Litharge	— 6 ,,
			strength					6.8	,,			
			Transverse	2.6	,,	12.4	,,					
			strength					14.0	,,			
2.	Not possible	205	Comp.	—13	,,	—13	,,	—13	,,	—do—	Dewaxed lemon shellac	— 40 ,,
			Shear	8.7	,,	—10	,,	—10	,,		Linseed oil	— 100 ,,
			Tensile	3.3	,,	5.7	,,	7.2	,,		Litharge	— 6 ,,
			Transverse	5.0	,,	7.0	,,	9.2	,,			
3.	115 gm/cm²	226	Comp.	6.5	,,	—13	,,	—13	,,	—do—	Dewaxed lemon shellac	— 40 ,,
			Shear	2.5	,,	—10	,,	—10	,,		Linseed oil	— 100 ,,
			Tensile	0.6	,,	6.4	,,	8.0	,,		Lime	— 6 ,,
			Transverse	4.0	,,	12	,,	27.6	,,			
4.	Not possible	219	Comp.	4.0	,,	—13	,,	—13	,,	—do—	Dewaxed lemon shellac	— 40 ,,
			Shear	1.5	,,	—10	,,	—10	,,		Linseed oil	— 100 ,,
			Tensile	1.6	,,	5.6	,,	6.6	,,		Glycerine	— 20 ,,
			Transverse	2.4	,,	12	,,	20	,,		Litharge	— 0.5 ,,
5.	Not possible	210	Comp.	12.0	,,	13	,,	13	,,	—do—	Dewaxed lemon shellac	— 40 ,,
			Shear	4.2	,,	8.8	,,	10.0	,,		Linseed oil	— 100 ,,
			Tensile	1.1	,,	4.0	,,	5.4	,,		Litharge	— 6 ,,
			Transverse	4.0	,,	13.0	,,	18	,,		Lime	— 6 ,,

nut shell liquid combination modified with urea and formalin in place of the melfolac varnish. The prepared sample immersed in dilute sulphuric acid for fifteen days was found to remain perfectly unaffected.

(iv) The following two problems were taken up for study as co-operative research after discussion with the Director, Jute, Technological Research Laboratories, Calcutta.

(a) *Adhesive for lamination of polythene and paper on hessian cloth.*

The adhesive used was one which had earlier been developed by this Institute (Sen, H.K. and Venugopalan, M., *Practical Applications of Recent Lac Research*, Orient Longmans, 1948, 71). It was prepared as follows. Lac (50 g) and cashew nut shell liquid (50 g) were heated together at 140-150°C for three hours. The product was then dissolved in *n*-butyl alcohol (100 g), and urea (4 g) and formalin (15 g) added. The heating was continued under reflux for a further period of 4 hours after which the solution was distilled under vacuum to recover the residual butyl alcohol (60 g), excess of formaldehyde and water of reaction. The thick syrupy residue was then thinned with a mixture of toluene (100 ml) and methylated spirit (100 ml). The resulting solution was applied on alkathene or paper by brush. The coated sheet was then laid over the hessian and the two passed at room temperature between two pressure rollers, after which they were allowed to dry.

The above composition was later simplified by replacing butyl alcohol with methylated spirit and avoiding the vacuum distillation for solvent recovery. This also worked equally satisfactorily.

The adhesion of alkathene to hessian was slightly less than that of paper. Samples were sent to one firm and they have approved the quality.

(b) *Water proofing of jute non-woven fabrics*

A solution of water-soluble lac boiled with 3 per cent urea on the weight of lac was used. Non-woven jute fabric was impregnated with this solution by dipping and the impregnated resin precipitated by dipping the fabric in dilute acid. The fabric was then washed with water and dried and finally pressed at 85°C at 800 lb per sq. inch. The sample is under test.

19. **Compilation of literature—Shellac Formulary**

A compilation has been made of all the formulae published in literature up to the end of 1965 regarding modifications and utilisation of lac. A preliminary draft (567 pages) has been completed. Rearrangement of the material chapterwise is more or less complete and preparation of the final draft has been taken up.

RESEARCHES CONTEMPLATED

As none of the above items have been completed, the studies are proposed to be continued. In addition, it is proposed to take up again for systematic study 'application of shellac-based primers and paints by the latest electro-deposition (electro-painting) technique.'

In case the staff position improves, it is also proposed to take up the items recommended by the 1966 Achievement Audit Committee but which could not be taken up so far due to shortage of staff.

Publications

Sl. No.	Author	Title of paper	Name of journal/Date of publication
ENTOMOLOGY DIVISION			
1.	CHAUHAN, N.S. & ROBERTSON, F.W.	Quantitative inheritance of red eye pigment in *Drosophilla melanogaster*.	*Genetical Research*, Vol. 8. 143-164, October, 1966.
2.	MEHRA, B.P.	Studies on the egg parasite of *Tessaratoma javanica* Thunberg (Hamiptera-Pentatomidae) with special reference to *Anastatus colemani* (Crawford) (Hymenoptera-Eupelmidae).	*The Indian Journal of Entomology*, Vol. 29(2), June, 1966.
3.	MEHRA, B.P. & SAH, B.N.	Bionomics of *Hemithia tritonaria* Walker (Lepidoptera-Geometridae) a pest of *Moghania macrophylla* (Willd).	*The Indian Journal of Entomology*, Vol. 28(3), September, 1966.
4.	PURKAYASTHA, B.K., BHATTACHARYA, A. & MEHRA, B.P.	Determination of the most suitable pruning methods and seasons for lac tree, *Schleichera oleosa* (Lour) Oken.	*The Indian Journal of Agricultural Science*, Vol. 36(2), April, 1966.
5.	PURKAYASTHA, B.K., MAJUMDAR, N & BHATTACHARYA, A.	Incidence of predators and feasibility of their control through hand picking in lac cultivation on bush type of hosts.	*The Indian Journal of Entomology*, Vol. 28(3), September, 1966.
6.	SAH, B.N. & MEHRA, B.P.	Bionomics of *Nephotery leucophacllia* Zell (Lepidophere: Phyralidac) a pest of *Moghania macrophylla* (Willd) O. Ktze.	*The Indian Journal of Entomology*, Vol. 28(4), December, 1966.

Sl. No.	Author	Title of Paper	Name of Journal/Date of Publication
7.	SRIVASTAVA, P.N. & VARSHNEY, R.K.	Composition of the Honey-dew excreted by lac insect-*Kerria lacca* (Homoptera : Coccoidac) I. Free amino acids.	*Entomologia exp. appl.* Vol. 9(2), 1966.
CHEMISTRY DIVISION			
1.	Kumar, Shravan.	A bright new hope for Shellac in wood finishing.	*Indian Shellac*, Vol. V, No. 1, 1966, p. 20.
2.	Kumar, Shravan & Misra, G.S.	Shellac: Its recent development in surface coatings.	*Paintindia*, Vol. 16, No. 1, 1966, p. 123.
3.	Kundu, P.K. & Kumar, Shravan.	Water thinned organic coating: Part. I, Lac Tung Oil—Phenolier resin.	*Paintindia*, Vol. 16, No. 6, 1966, p. 27.
4.	Misra, G.S. & Tripathi, S.K.M.	Lac—Some recent applications.	*Science Reporter*, May, 1966.
5.	Sahu, T. & Misra, G.S.	Shellac-Graft copolymers Part I.	*Indian Journal of Technology*, Vol. 4, 1966, pp. 370-373.
6.	Sen Gupta, S.C.	Some minor constituent acids of lac resin.	*The Proceedings of the National Academy of Sciences of India*, Sec. A, Vol. 35 (4), 1965.

Extension

1. *Cultivation of lac.* As was reported last year (*Annu. Rep.* 1965–66), all activities relating to extension of lac cultivation used to be the responsibility of the then Chief Lac Development Officer under a separate wing of the now defunct Indian Lac Cess Committee. With the abolition of the Committee, these activities have now developed on the newly constituted Regional Office for Lac Development which is functioning directly under the Ministry of Food and Agriculture. The function of this Institute, as before, is thus limited to providing the necessary technical assistance to those interested. The principal activity in this regard during the period under report was the forecasting of the date of larval emergence on the basis of examination of stick samples received from interested parties. Another major activity was this Institute's collaboration with the Forest Department of the Bihar Government in their large-scale cultivation experiments of Lac at Kundri and the establishment and maintenance of a *Kusmi* brood lac-*cum*-demonstration farm at Maheshpur–Sirka. In both cases, the Forest Department provides the host trees, labour and other incidental requirements and produces lac, and the Entomology Division of this Institute provides the technical guidance.

The work carried out during the period under report is described below:

(a) LARGE-SCALE CULTIVATION EXPERIMENTS ON *palas* AT KUNDRI (DIST. PALAMAU): These experiments have been going on in Kundri Lac Orchard for the past several years. The Orchard has a total of about 20,000 *palas* trees. During 1966, a total of 2,905.00 kg of scraped lac and 2,209.00 kg of brood lac was produced in this orchard. These were much lower than the quantities produced during the previous years; because of the severe drought and very hot summer in the area. The entire yield of brood lac was used up for inoculation for the subsequent crop and there was no surplus for sale.

Sale of sticklac fetched a total revenue of Rs. 2794.26 as against the total expenditure of Rs. 2080.46 resulting in a net profit of Rs. 713.80.

(b) ESTABLISHMENT AND MAINTENANCE OF *kusmi* BROOD LAC-CUM- DEMONSTRATION FARM AT MAHESHPUR—SIRKA (DIST. RANCHI): As outlined already (*Annu. Rep.* 1965–66), this farm has been set up by the Bihar Forest Department to stimulate *kusmi* lac production and to study the behaviour of *kusum* trees in the production of lac during different seasons. Survey had been made and pruning carried out in July 1965.

During the period under report, two experiments were laid out on the basis of the (600) trees already surveyed. The work was initiated by the first primary inoculation by the end of July 1966 on trees which had already been pruned previously for the purpose as also some unpruned ones to reduce the time gap. A total of two hundred trees were inoculated with brood supplied by the Forest Department for two experiments to be conducted simultaneously. The crop by the end of the year was in a very good condition.

2. *Training and advisory service.* Six trainees (five from Bihar and one from Madras) received training in Improved Methods of Lac Cultivation during the first session from April 7 to September 30, 1966. In the next session from 7th October, 1966 to 31st March, 1967, 12 trainees (six from M.P., three from Maharashtra, two from U.P. and one from Rajasthan) joined the courses and received the training.

Lectures on improved methods of lac cultivation were also delivered at Forest Guard Schools at Mahilong and Betla.

Specimens of lac insects and other insects, viz., predators and parasites, samples of lac encrustation on different hosts, brochures and literature on lac cultivation were despatched to colleges, Vigyan Bhavans and schools whenever asked. Various other technical queries were attended to.

3. *Processing and utilisation of lac.* Unlike cultivation, extension activities in regard to processing and utilisation aspect of lac are the complete responsibility of this Institute as far as industries in India are concerned. For this purpose, the Institute is maintaining a Utilisation Section. Although a reasonable team has been provided for, this Section had, during the period under report, only the Officer-in-Charge, namely the Senior Scientific Officer, in position. He had, therefore, to draw upon the assistance of the Research Staff of the Chemistry Division, from time to time, for carrying on the allotted activities of the Section, namely, technical service, developmental activities, publicity and propaganda, etc.

(a) TECHNICAL SERVICE: Among the more important parties to whom technical assistance was extended in regard to the processing aspects, mention may be made of the following:

(i) The Bihar State Co-operative Lac Marketing Federation who were assisted in the planning and setting up of their lac processing factory and its equipment.

(ii) A leading shellac manufacturer was assisted in getting over his initial difficulties in the installation and operation of three autoclaves for shellac manufacture in his factory at Balarampur. It will be recalled that the autoclave method of shellac refining is a process developed by this Institute.

(iii) A leading wax processing factory at Ranchi was assisted in the collection of the lac dye mud for recovery of lac wax.

In regard to extension of Utilisation of Lac the more important activities were the following:

(i) A shellac bond of adequate fineness was prepared and supplied to the Heavy Electricals (I) Ltd., Bhopal for use as the bond powder for manufacture of micanite in replacement of an imported shellac counterpart. At the request of the party, bulk quantities were also supplied as a special case for their production pending their own arrangements with other parties for the regular supply of this material.

(ii) A leading rubber factory was assisted in obtaining suitable quality of shellac for use along with rubber. A sizeable quantity of the material was used by this party.

(iii) A printing ink manufacturer in Kenya, East Africa, was supplied samples of dewaxed water-soluble lac for use in their printing inks. As the party, apparently satisfied with the material, wanted to import regular supplies, the information was passed on to the Shellac Export Promotion Council for necessary action. Water-soluble lac was also in regular use within this country for photo-engraving as well as for coating earthenware.

(iv) A leather cloth (PVC cloth) manufacturer was induced to try out shellac ester as plasticizer for PVC. The party reported that the product served the purpose, although the shade was a bit too dark.

(v) A composition based on shellac was developed to replace imported Dennison Waxes used for testing surface strength of paper and supplied to a leading paper factory. The factory has found the sample satisfactory up to a certain degree of hardness.

(b) DEVELOPMENTAL ACTIVITIES: Schemes for the setting up of small-scale shellac factories as well as for the production of shellac products were supplied, on request, to the Industries Department, Government of Bihar and to the Community Project Officer (Industries), Ranchi. The latter, it is understood, has passed on the information to different Co-operative Societies.

(c) PUBLICITY AND PROPAGANDA: All possible assistance was extended to the Shellac Export Promotion Council in the production of a feature film on lac which was produced on their behalf by the Metrotone News Agency. Colour transparencies on different aspects of lac were also supplied to the Botanical Survey of India for displaying in the Indian Museum at Calcutta.

SALE OF SPECIAL SHELLACS FROM PILOT PRODUCTION UNIT

	Sales					
	April–Dec. 1966		April–Dec. 1965		April–Dec. 1964	
Product	Quantity kg	Values Rs P	Quantity kg	Values Rs P	Quantity kg	Values Rs P
Bleached lac, refined, BRF grade	209.45	1669.60	195.65	1565.20	589.80	4214.
Bleached lac, regular, BR grade	687.00	4583.60	210.45	1438.15	468.40	2711.59
Water-soluble lac, DL grade	144.50	994.52	144.16	1008.75	131.20	836.10
Water-soluble lac, AL grade	44.15	264.90	46.50	279.00	83.60	454.53
Autoclave shellac, ASK grade	2712.50	12030.40	1664.10	6296.40	676.35	1827.80
Miscellaneous (Hydrolysed lacs, lac wax, varnishes etc.).		744.30		452.00		409.70
	3,797.60	20287.32	2,260.86	11039.50	1,949.35	10454.16

(d) PILOT PRODUCTION UNIT : The Unit continued to produce and sell to the interested consumers special shellacs developed by this Institute. The quantities produced and their sale values during the period under report are indicated in the table on page 59 together with the data for the corresponding period of the previous two years for comparison.

All the seedlacs required for the manufacture of bleached lac and autoclave shellac were prepared by the Unit itself from sticklac purchased from the market.

Summary

The research work of the Institute has been discussed under two parts: (i) Biological, (ii) Chemical and Technological.

A. BIOLOGICAL INVESTIGATIONS

During the year, studies on two problems were concluded, and two other problems were taken up. Besides, the studies already in hand were continued. The important observations are as follows:

Potentiality trials. (i) *On ber.* Potentiality trials on *ber* were conducted for determining the optimum density of larval settlement for the host in *Katki* season and were concluded. The results showed that application of twice the usual brood rate (one metre of brood for every 25 metres of inoculable shoots) gives the maximum yields of sticklac.

Another experiment was initiated with the object of determining the earliest period when broodlac could be harvested to enable its despatch to distant places, without any detriment to larval emergence and subsequent development and production of lac.

(ii) *On palas.* The experiment on determination of optimum density of larval settlement for *palas* suffered due to the prevailing drought and severe summer, in that no crop was available from some of the treatments which were harvested in October, 1966 the other treatments having produced sticklac when harvested in April earlier. Hence no conclusion or results were available.

In regard to the proper time of harvesting-*cum*-pruning of *palas* during April–May, confirmatory results regarding higher yields of crops per tree were obtained when this was carried out either partially or fully between 15th and 20th April. The experiment is to be concluded after the harvest of 1967.

In the case of a similar experiment during October/November and with different rates of inoculation higher amount of broodlac and sticklac was obtained with light inoculation (100 g per tree). The conclusions are yet to be confirmed.

Regarding advance cutting of *palas* brood, it has been observed that this is not practicable more than two weeks before the anticipated date of larval emergence.

(iii) *On other hosts.* The study could not be carried out on *bhalia* (*Moghania macrophylla*) due to poor growth of seedlings and non-availability of manure for which transplanting could not be done. Further attempts are being made for raising the suitable plants.

Evolution of cultivation practices

Evolution of cultivation techniques are being attempted to maximise yield with simultaneous reduction in the cost of cultivation. In respect of *palas*, in the third successive trial, the data obtained was poor in regard to yields due to extreme drought and severe summer prevailing in the area (*Kundri*). Hence no conclusions could be arrived at.

Regarding *kusum*, a partial crop was obtained from two treatments and a full crop from the third treatment which were good. The standing crop will be a very good one after a long gap, and is to be harvested by the end of January, 1967. It is too early to draw any conclusions at this stage.

Arboricultural studies

With regard to the technique of raising a plantation of *bhalia* bushes, the study has been concluded. It has been confirmed that seedlings raised in April and transplanted in July at the rate of two per pit give the best results in regard to the height, growth and length of shoots.

Bushes of *bhalia* were raised with three different spacings in 3 coupes for raising consecutive lac crops. Freshly transplanted plants as well as pruned ones showed vigorous growth during June to August which continued till October. So far as growth is concerned bushes with a spacing of 1.83×1.83 metres (6 ft×6ft) gave the best results. These plants were in the optimum conditions at the time of inoculation which was done in July 1966. A good crop is expected.

Manuring experiments with organic and inorganic fertilizers for *bhalia* bushes were continued. Significant increases in yield were obtained with manurings. Differential effects between the two types of manures, if any, however, remain to be assessed as consistent results were not available.

Albizzia lucida and a set of *ber* plants have been trained into bushes, while some more *ber*, *palas* and *kusum* are still in the process of being trained *A. lucida* has given good results as a bush host; the yield ratio in *Baisakhi* crop was 1 :30.

Experiments were continued for finding out alternate hosts for raising *Kusmi* strain of lac insects. Various experiments are being carried out in which *A. lucida* and *O. oojeinensis* are being put to use either (i) alternated with *kusum*, or (ii) without any alternation, and again (iii) *A. lucida* alternated with *M. macrophylla* for raising the respective *Jethwi* and *Aghani* crops. *Jethwi* crop raised on these two alternate hosts were good and the brood obtained was used on *kusum* for raising *Aghani* crop. As a continuous host, both the hosts produced crops in *Jethwi* 1966 and the brood obtained was utilised again on the same hosts for *Aghani* crops which are progressing nicely.

A. lucida in alternation with *M. macrophylla* during *Jethwi* 1966 crop gave a good yield of broodlac. The yield was 3.2 times the quantity of brood used. This plant thus proved to be a suitable alternate host for raising *Jethwi* crops and compares favourably with *kusum* itself.

Two new studies were initiated during the year. These are (i) evolution of a high quality strain for lac cultivation on *palas* and (ii) study of the pleiotropic effects of the yellow gene. Shoots of *palas* trees were inoculated with *Kusum* strain of insects. A very small number of females (5 out of 5,000) survived, three of which reproducing according to *Kusum* schedule. These were used to raise the subsequent generation, again on *palas*. The survival rate this time was better, 8 out of 800 progressing normally.

Biological and ecological studies

Life history studies of *Hypena iconicalis* Walk., *Platypeplus aprobola* Meyr. and *Dasychira mendosa* Hubn (form *fusiformis* Walk.) were completed. Studies were continued on *Belippa laleana* Moore, *Prodenia litura* Boisd., and a Limacodid and a Coreid, all pests of host trees. Control measures of the insects studied will be taken up henceforth.

Survey of enemies of lac insect and their parasites were continued by raising all the four crops druing the year on four different hosts and the insects which emerged from samples caged were identified and recorded. During *Baisakhi* and *Jethwi* crops predators were quite prominent and during *Katki* and *Aghani* (part) both predators and parasites were numerous.

With regard to seasonal incidence of *E. amabilis* and *H. pulverea* on lac crops raised on *M. macrophylla*, two seasonal crops were raised and the complete assessment during the *Aghani* season has been made. A rather high incidence of both the predators was perceptible from the second fortnight of September 1966 to first fortnight of December 1966.

Biological control of lac enemies

Field scale trials of spraying thuricide for controlling the predators were carried out during *Baisakhi*, *Jethwi* and *Katki* crops and trials are continuing on *Aghani* crop. The *Baisakhi* crop was a failure. During *Jethwi* and *Katki* crops, significant increases in yields were obtained with 0.02 to 0.04 per cent concentration of the thuricide, weekly sprayings producing the best results. A high degree of effectiveness was obtained in the control by the bacillus.

A survey of pathogenic organisms in lac insect predators was initiated during the year. Preliminary observations revealed a number of pathogenic organisms responsible for causing diseases in the immature stages of the predators.

Chemical control of insect parasites and predators

Crops were raised on *M. macrophylla* for spraying with different insecticides. Unfortunately, due to poor development of crop, sufficient number of bushes could not be used for the purpose. New crops have been raised on *bhalia* bushes for *Aghani* 1966–67 crops and spraying at intervals of 10 days are being carried out on these. Assessment will be made after the crop is harvested next year.

Regional field station

The usual routine investigations were carried out at Damoh and Mirzapur on the local host *ghont* in addition to *ber* and *palas*. The results of different experiments had not been encouraging as the crop raised failed at both places. During the period under report, preparations were going on to shift the station at Umaria to Dharamjaigarh.

Training and advisory service

Six trainees received training in the improved methods of lac cultivation during the first session from April to September 1966. In the next session, 12 trainees were receiving training.

Routine enquiries were answered and investigations carried out and advice, etc., given where necessary.

B. CHEMICAL AND TECHNOLOGICAL

The research in the Chemistry Division had embraced all aspects of interest to the processing, standardising and utilisation of lac and its by-products, as well as fundamental chemical and physico-chemical studies in order to understand the constitution and behaviour of lac to facilitate its further modification to enhance its properties in desired directions.

1. Lac resin has been known to contain a neutral fraction and a mixture of free fatty acids, and the resin itself can be separated by the inoccueous solvent, ether, into soluble and insoluble portions, the former being known as soft resin and the latter hard resin. Fundamental studies during the period under report included methods of separation of the constituents of this neutral fraction, the free acid mixture and soft resin. By applying the latest techniques of organic chemistry, namely, thin layer chromatography and column chromatography, a number of fractions have been obtained which are under further study. It was also noted that during esterification of lac under the conventional methods, lac also breaks down into its constituent acids and that the ester that is finally obtained is not the ester of the original lac but a mixture of the esters of its different constituent acids.

2. Lac has been modified by grafting/copolymerisation with synthetic monomers, and their mixture with acrylamide. Positive evidence of copolymerisation taking place has been obtained. It has also been found that ethyl acrylate (65 per cent on the weight of lac) gives the best graft polymer as far as use of the resulting emulsions for surface coatings is concerned.

3. Attempts were made to isolate improved fractions of shellac by addition of aqueous solutions of electrolytes into a spirit solution of the lac but these did not meet with much success.

A new technique developed earlier to produce hydrolysed lac from seedlac and shellac was standardised and the method was extended to production of hydrolysed lac from lac reclaimed from a by-product of lac industry, namely, *molamma*. Aleuritic acid, a crystalline colourless acid constituent of lac resin of established commercial value, had been obtained by treatment of lac with caustic soda resulting in an yield of about 20 per cent. It was found that by carrying out the hydrolysis with alkali saturated with sodium chloride and in the presence of sodium sulphite added two days after treating the lac with the alkali, the yield could be raised to 25 per cent.

Wax is a valuable by-product, a good deal of which is being lost during washing of sticklac into seedlac. Acid treatment of this wash water has been shown to precipitate a sludge which carried down this wax and from which wax had been isolated in a Semi-Pilot Plant established in the Institute to the extent of 73 per cent. A slight modification, namely, providing an external heating arrangement round the extractor, has resulted in obtaining an increased (89.5 per cent) yield of the wax in a shorter number of extractions (9 instead of 12).

After removing this sludge, the acid-treated lac wash water retains a small portion of the water-soluble dye of lac which has been isolated by precipitation as calcium salt and regeneration with acid. The yield was 0.23–0.25 per cent of the sticklac worked.

4. Urea, one of the most efficient and cheapest accelerators for lac, has now been utilised as a modifier by heating with thrice its weights of shellac to produce a modified form of the latter of higher melting point and improved blush resistance.

5. Determination of the age (period of storage) of lac had been and still is an unsolved problem of the lac industry. Specific heat, a physical constant that can be determined with a great degree of accuracy, was known to be a property of lac which changed gradually with increased period of storage or otherwise deterioration of the lac. In order to correlate, if possible, the specific heat with the period of storage, six samples of typical seedlacs produced from sticklacs of known histories, had been under storage in this Institute since July, 1964 and their specific heats determined from time to time. It has been found that there has been a drop of about 7.7 to 10 per cent at the end of about 18 months after which, however, the drop has not been appreciable.

6. Water-based coatings are the latest trend in paint technology and the Institute had developed two water thinned red oxide primers for steel. One of these has been further examined with the incorporation of corrosion inhibiting chemicals for further improvement. Of five chemicals studied, sodium nitrite gave the best scratch hardness while *n*-butylamine gave the best overall performance required of a high class primer. Another primer based entirely on indigenous raw materials has also been evolved which also has been found to be quite satisfactory as air drying and baking types in all experiments so far.

7. Shellac had always been a desirable additive to rubber. Systematic studies have now shown that even better than shellac is a modified shellac produced by fusing together shellac (70 parts) and epoxy resin (30 parts) at 150°C for about 15 minutes. Still better is an ethylene glycol modified shellac produced by boiling, under reflux, shellac with ethylene glycol in the presence of concentrated sulphuric acid. The modified product incorporated into styrene-butadiene rubber served both as a processing aid as well as for improving modulus, tensile strength, tear resistance and hardness of the rubber.

8. Shellac has been found to produce moulding powders of the thermosetting

type by compounding with urea/formaldehyde resin and jute stick dust as filler. It has been found that if the urea resin content is raised beyond 50 per cent on the weight of shellac, the flow and fusibility of the resulting powder are adversely affected.

Incorporation of butyl ester of hydrolysed lac as well as that of shellac itself has been found to reduce the brittleness of polyvinyl chloride (PVC) moulded articles. Attractive articles could be made from PVC compounded with the butyl esters and litharge as stabilizer (for the PVC).

9. (i) Shellac varnish was modified by blending with unsaturated polyesters for producing improved surface coatings. Addition of cobalt has been found to improve the hardness of air-dried films by nearly 50 per cent.

(ii) Shellac was also modified by treatment with maleic resin. The modified product containing 70 parts of shellac and 30 parts of the resin with 0.3 per cent of cobalt gave a French polish of improved heat and water resistance. This also served as a baking varnish of outstanding water resistance, the films not blushing on continuous immersion even up to 15 days.

(iii) When shellac (55 parts) was first blended with castor oil (45 parts) by heating together at about 250°C in the presence of a small amount (2 parts) of lime, and the blend, in MIBK or toluene solution, treated with toluene diisocyanate (30 parts), the films obtained on air drying possessed good scratch hardness, gloss and elasticity. They also resisted 50 hard rubs with cotton pads soaked in alcohol, acetone or toluene. The films also showed good resistance to water, 5 per cent caustic soda and 6 normal sulphuric acid.

(iv) Another useful modifier for shellac has been found in allyl alcohol. Shellac, on treatment with this alcohol in the presence of concentrated sulphuric acid as catalyst, resulted in an ether ester which, in the presence of 0.2 per cent cobalt, dried in air or on backing, to produce hard, glossy and elastic coatings. The material in MIBK or toluene solution when treated with 20 per cent of its weight of toluene diisocyanate also yielded, on air drying, hard, glossy and elastic coatings resistant to heat, water, 10 per cent sodium carbonate, 5 per cent caustic soda, etc. They also resisted 50 hard rubs with cotton wool soaked in toluene, alcohol and acetone. Pigmented products, produced by pigmentation of the ether ester and subsequent modification with the isocyanate, produced spirit paints, the air-dried films of which were hard, and exceptoinally glossy. The ether/ester also dissolves in synthetic monomers; a solution in methyl methacrylate was found to set to a solid gel at room temperature in the presence of benzoyl peroxide indicating possibilities for use as solventless coating.

(v) Natural weathering tests of shellac single pack etch primers based on shellac, malic acid and zinc tetroxychromate had been continued. The primer films were found to be satisfactory after 24 months' exposure on aluminium and galvanised iron surfaces. Regarding the area where a synthetic alkyd (finish) coat had been applied, this was also satisfactory on galvanised iron but on aluminium the finish coat started showing minor cracks at the end of 18 months. Attempts to improve the corrosion resistance of shellac etch primers on steel have not been very successful. Preliminary experiments have shown that a zinc free pigment (zinc being an imported item), namely, barium potassium chromate is also likely to be satisfactory for use in shellac etch primers.

(vi) Improved shellac spirit paints eliminating the weaknesses of poor heat and water resistance of conventional shellac paints have been developed by grinding shellac melamine resin (heat and water proof) varnish with various pigments. These new paints could be applied by brush as well as by spray to produce films of good mechanical strength and resistance to scrubbing, heat and water. The single pack acid-catalysed wood lacquer based on shellac, urea resin and toluene sulphonic acid which had been found to be satisfactory for use as a heat and waterproof finish for wood, has now been found to have good shelf life also. The above varnish without the acid catalyst has also been found to be a satisfactory coating material of the baking type for use on the inside of tin containers for the storage of shellac spirit varnishes.

10. (i) Shellac blended with linseed oil in the presence of lime has been found to be a satisfactory material for use as binder for sand moulds in place of linseed oil. The superiority of the former, if any, is yet to be assessed.

(ii) A number of compositions based on shellac which are known to produce hard, elastic films on baking have been tried for the production of enamelled copper wires, but not with complete success.

(iii) Non-woven jute fabric was soaked in spirit varnishes containing dewaxed shellac and spirit-soluble melamine resin on the one hand and lac modified with cashew shell liquid and urea and formalin on the other. This was for use of the fabric as separator in storage batteries. Continuous immersion in battery sulphuric acid for about 15 days showed that while the former bacame brittle the latter was satisfactory.

(iv) Investigations for extending the use of lac in conjunction with jute have been taken up as a cooperative venture after discussion with the Director, Jute Technological Research Laboratories, Calcutta. A shellac composition based on lac, cashew shell liquid, urea and formalin, already developed in this Institute as a general purpose adhesive, was tried as an adhesive for the lamination of polythene and paper on hessian cloth. Samples produced have been approved by a leading Firm.

Another problem of investigation was water proofing of jute non-woven fabric. Water soluble lac boiled with 3 per cent of urea was used to impregnate the fabric and the resin was precipitated *in situ* by dipping the impregnated fabric in dilute acid. The treated fabric was finally washed, dried and pressed.

11. A compilation has been made of all the formulae published in literature up to the end of 1955 regarding modifications and utilisation of lac. The material has been, almost completely, rearranged into chapters and preparation of the final draft has been taken up with a view to its publication.

Personnel

(A) Statement showing appointments, promotions, resignations, retirements, etc., during April–December, 1966

Division or Section		Name	Post to which appointed	Date
		(a) Appointments		
Admn. Audit and Accounts Section	1.	Shri Uma Dutta	Administrative Officer	1-4-1966
	2.	,, H.N. Prasad	Jr. Accounts Officer	8-8-1966
	3.	,, B.P. Sen	Superintendent	1-4-1966
	4.	,, K.K. Mustaufi	Assistant	1-4-1966
	5.	,, S.N. Sharma	Assistant	1-4-1966
	6.	,, S.N. Prasad	Assistant	1-4-1966
	7.	,, R.K. Singh	Assistant	1-4-1966
	8.	,, R.N. Prasad	Assistant	7-10-1966
	9.	,, Tota Ram	Peon	1-4-1966
	10.	,, Jogeshwar Ram	Peon	1-4-1966
	11.	,, Elias Lakra	Peon	1-4-1966
		(b) Promotions		
	1.	Shri K.K. Mustaufi	Superintendent	1-9-1966
	2.	,, P.K. Choudhury	Assistant	3-9-1966
	3.	,, H.S. Munda	Upper Division Clerk	2-11-1966
	4.	,, R.P. Singh	Upper Division Clerk	2-11-1966
		(c) Resignations		
Entomology Division	1.	Shri R.K. Varshney	Senior Research Assistant	18-10-1966
	2.	,, R.M. Sundaram	Research Assistant	18-10-1966
	3.	,, V.D .Rai	-do- (Terminated)	13-10-1966
	4.	,, H.L. Ravidas	Laboratory Assistant	3-5-1966
	5.	,, Kunji Pattar	Field Chowkidar	31-8-1967
	6.	,, Ramkrishna	-do-	10-7-1967
	7.	,, Hari Singh	-do-	7-6-1967
Chemistry Division	1.	,, R. Banerjee	Senior Research Assistant	16-7-1966 (A/N)
	2.	,, P.K. Kundu	Research Assistant	11-5-1966 (A/N)
	3.	,, P.K.S. Roy,	Research Assistant	3-11-1966 (A/N)
		(d) Retirements		
Administrative Section	1.	Shri B.P. Sen	Superintendent	12-8-1966
Entomology Division	1.	,, Jugal Singh	Laboratory Attendant	1-7-1966

(B) STAFF DIVISIONWISE

Sl. No.	Name of the post	Sanctioned	Staff in position as on 31-12-1966
1	2	3	4
1.	Director	1	Dr. G.S. Misra
	Entomology Division		
2.	Entomologist	1	Dr. A. Bhattacharya
3.	Scientific Officer (Cultivation)	1	Shri B.P. Mehra (on deputation to Canada)
4.	Scientific Officer (Field Station)	1	Shri C.P. Malhotra
5.	Scientific Officer (Insect Genetics)	1	Shri N.S. Chauban
6.	Scientific Officer (Arboriculture)	1	Vacant
7.	Scientific Officer (Physiology)	1	Vacant
8.	Scientific Officer (Biology)	1	Vacant
9.	Senior Research Assistants	8	1. B.K. Purkayastha 2. R.S. Gokulpure 3. A.H. Naqvi 4. S.M. Kulkarni 5. N. Majumdar 6. to (8) Vacant
10.	Instructor	1	Vacant
11.	Research Assistants	16	1. Shri R.C. Misra 2. ,, P. Sen 3. ,, A.K. Sen 4. ,, Saligram Chowdhury 5. ,, U.P. Griyaghey 6. ,, B.N. Sah
	J.R.A.s working against the vacancies of Research Assistant	—	7. ,, M.K. Chowdhury 8. ,, J.M. Das Gupta 9. ,, R.C. Maurya
			10. to (16) Vacant
12.	Senior Artist-*cum*-Photographer	1	Shri R.L. Singh
13.	Junior Artist-*cum*-Photographer	1	,, Pyare Das
14.	Junior Field Assistants	4	Vacant

1	2	3	4
15.	Fieldman	17	1. Shri A.C. Chatterjee 2. „ S.N. Sharma 3. „ H.R. Munda 4. „ Sant Kumar 5. „ R.K. Paul 6. „ R.S. Maliya 7. „ K.C. Jain 8. „ Jawahar Lall 9. „ B.D. Tiwary 10. „ Shiv Shankar Prasad (11 to 17) Vacant
16.	Field Plantation and Store Assistant	1	Shri G. Lakra
17.	Insect Collection Tender	1	Md. Ali Ansari
18.	Laboratory Assistants	10	1. Mrs. N. Nandy 2. Shri Azmer Hussain 3. „ K.L. Chowdhury 4. „ D.D. Prasad 5. „ G.K. Jha 6. „ R.D. Pathak 7 to 10 Vacant
19.	Museum Assistant	1	Mrs. Sati Guha
20.	Laboratory Attendant	10	1. Shri Mani Mahto 2. „ Jagrnath Oraon 3. „ Dema Oraon 4. „ Yakub Tirkey 5. „ Md. Sharif 6. „ Kamal Prasad 7. „ S.K. Chatterjee 8. „ H.N. Shukla 9. „ Mohar Sahu 10. „ Gendu Bowri
21.	Peon	2	1. „ Shyamlal Ram 2. „ Gandur Singh
22.	Mali	2	1. „ Buddhua Oraon 2. „ Maria Oraon
23.	Durwan	4	1. „ Jiwan Lal 2. „ Kashi Nath 3. „ Chhote Lal Dhimar 4. Vacant
24	Field Chowkidar (Congt. Staff)	18	1. Shri Dubraj Munda 2. „ Mukund Pahan 3. „ Agnu Munda 4. „ Keshar Bhuian 5. „ Madhuri Bhuian 6 to 18 Vacant

1	2	3	4
		Chemistry Division	
1.	Senior Scientific Officer (Organic)	1	Shri Y. Sankaranarayanan
2.	Senior Scientific Officer (Utilisation)	1	Dr. T. Bhowmik
3.	Scientific Officer (Physical)	1	Dr. P.R. Bhattacharya
4.	Scientific Officer (Applied)	1	Shri S.C. Sen Gupta
5.	Scientific Officer (Decorative)	1	Shri Shravan Kumar
6.	Scientific Officer (Factory)	1	Shri B.B. Khanna
7.	Scientific Officer (Utilisation)	1	Vacant
8.	Junior Scientific Officer	1	Shri P.K. Ghose
9.	Senior Research Assistant	6	1. Shri A.K. Ghose 2. „ P. C. Ghose 3. „ A. Kumar 4 to 6 Vacant
10.	Research Assistant	17	1. Shri A. Rahaman 2. „ P.C. Gupta 3. „ T. Sahu 4. „ R.K. Banerjee 5. „ S.K.M. Tripathi 6. „ August Pandey 7. „ M. Mukherjee 8. „ Md. Islam 9. „ S.C. Agrawal 10. „ G.C. Sharma 11. to 17 Vacant
11.	Senior Analyst	2	Vacant
12.	Analyst	3	1. Shri L.C. Misra 2. „ B. Prasad Banerjee 3. „ R. Prasad
13.	Junior Analyst	3	1. „ K.M. Das 2. „ B.C. Srivastava 3. Vacant
14.	Glass Blower	1	Shri S.K. Dey

1	2	3	4
15.	Laboratory Assistant	11	1. ,, Dominic Runda 2. ,, N. Minz 3. ,, G.M. Borkar 4. ,, B.B. Chakraborty 5. ,, Nagendra Mahto 6. ,, U. Sahay 7. ,, B. Majumdar 8. ,, B.P. Keshri 9 to 11 Vacant
16.	Laboratory Attendant	10	1. Shri Masidas Minz 2. ,, Siba Baraik 3. ,, Mangta Oraon 4. ,, Gopesar Misra 5. ,, P.B. Sen 6. ,, Md. Ghaseet 7. ,, Chinmoy Sengupta 8. ,, Dukha Oraon 9. ,, Chedilal 10 ,, Ram Charitar Tiwary
17.	Peon	4	1. ,, Birsa Oraon 2. ,, Nathanial Kachhap 3. ,, Shiv Charan Gope 4. ,, Dhadhoo Mahto
18.	Durwan	3	1. ,, S.K. Deogharia 2. ,, Hari Ram 3. Vacant
19.	Factory Boy	1	,, Hanuk Tigga
20.	Melter	1	,, Sukra Oraon
21.	Stretcher	1	,, Lohra Oraon

Administrative and Audit and Accounts Section

1	2	3	4
1.	Administrative Officer	1	,, Uma Dutta
2.	Junior Accounts Officer	1	,, H.N. Prasad
3.	Superintendent	1	K.K. Mustaufi
4.	T.A. to Director	1	Vacant
5.	Assistants	8	1. ,, S.K. Sircar 2. ,, L.M. Nandy 3. ,, S.N. Sharma 4. ,, S.N. Prasad 5. ,, R.K. Singh 6. ,, P.K. Choudhury 7. ,, R.N. Prasad 8. Vacant

1	2	3	4
6.	Librarian	1	R.P. Indwar
7.	Stenographer Grade I	1	,, M.T. Rughani
8.	Upper Division Clerk	6	1. Shri D.P. Sen Gupta 2. ,, H.S. Munda 3. ,, R.P. Singh 4 to 6 Vacant
9.	Store Keeper	1	Shri Enamul Haque
10.	Steno-typist	2	1. ,, P.N. Sivankutty 2. Vacant
11.	Lower Division Clerk	15	1. Miss Sibani Hazra 2. Shri Musafir Singh 3. ,, Samiullah 4. ,, A.K. Choudhury 5. ,, Anwarul Haque 6. ,, E. Tirkey 7. ,, K.P. Kesri 8. ,, Rambaran Singh 9. ,, Kuldip Pandey 10 to 15 Vacant
12.	Daftari	2	1. Shri Martin Beck 2. Vacant
13.	Peons	7	1. Shri Budhua Oraon 2. ,, Jagdish Ram 3. ,, Pahna Lakra 4. ,, Mahadeo Mahto 5. ,, Tota Ram 6. ,, Jogeshwar Ram 7. Vacant
14.	Farash	2	1. Shri Mangra Oraon 2. ,, Tutung Bihan
	Mechanical Section		
1.	Chief Mechanic	1	Shri K.N. Sinha
2.	Assistant Mechanic	1	Vacant
3.	Instrument Maker	1	,, M. Kujur
4.	Turner	1	,, A.S. Manoranjan
5.	Jeep Driver	1	,, Jagdish Ram

1.	2	3	4
6.	Boiler Attendant	1	Vacant
7.	Tindal	1	„ Tulsi Ram
8.	Carpenter	1	„ Balku Lohar
9.	Khalasi	1	„ Bhudhua Oraon
10.	Gas Plant Attendant	1	„ Lachchan Oraon
		Estate	
1.	Estate Care Taker	1	Md. Saheb Ali
2.	Labour Supervisor	1	Shri Dharam Nath Mahto
3.	Armed Guard	1	„ Jamun Jha
4.	Chowkidars and Durwans	14	1. „ Sahadeo Ram 2. „ Abdul Mohalib 3. „ Hawaldar Singh 4. „ Mahadeo (Lodhaman) 5. „ Mahadeo (Khijri) 6. „ Premdas Banerjee 7. „ Pryag Mahto 8. „ Deolal Singh 9. „ Mohan Bahadur 10. „ Ramdas Mishra 11. „ Chatru Oraon 12. „ Sanicharwa Oraon 13. „ Ramgulam Singh 14. „ Jogendra Pathak
5.	Sweepers	5	1. „ Sanicharwa Ram 2. „ Punesar Ram 3. „ Budhu Ram 4. „ Patras Bandu 5. Smt. Mundri
6.	Bullock-keeper	2	1. „ Phekua Munda 2. Vacant (1)
		Medical Unit	
1.	Authorised Medical Attendant	1	Dr. S.S. Sahay
2.	Compounder	1	Shri B.N. Munda

List of regional names used in this Annual Report together with their technical and common English names

Hindi name	*Technical name*	*English name*
amaltas	*Cassia fistula* L.	Golden-shower
bargad	*Ficus bengalensis* L.	Banyan
bansa	*Albizzia odoratissima* Benth.	Solid bamboo
ber	*Zizyphus mauritiana* Lamk. (Syn. *Z. jujuba* Lam. non Mill)	Jujube Jujube
bhalia	*Moghania macrophylla* (Willd.) O. Kuntze (Syn. *Flemingia congesta* Roxb. var. *semialata* Bak).	
dhoben	*Dalbergia paniculata* Roxb.	
galwang	*Albizzia lucida* Benth.	
dudhi	*Wrightia tinctoria* R. Br. (Syn. *W. rothii* G. Don; *Nerium tinctorum* Roxb.)	Sweet indrajao
gular	*Ficus recemosa* L. (Syn. *Ficus glomerata* Roxb.)	Cluster fig
karonda	*Carissa carandas* L.	
katmouli	*Bauhinia racemosa* Lam.	
khair	*Acacia catechu* (L.f.) Willd.	Cutch tree
kusum	*Schleichera oleosa* (Lour.) Oken (*S. trijuga* Willd., *Pistacia oleosa* Lour.)	Lac tree
makai	*Zizyphus oenoplia* Mill	
nira	*Samanea saman* (Jacq.) Merr.	Rain tree
palas	*Butea monosperma* (Lamk.) Taubert (Syn. *B. frondosa* Koenig ex Roxb.)	Flame-of-the-forest
pipal	*Ficus religiosa* L.	Pipal tree, Bo-tree
renja	*Acacia leucophloea* Willd.	
rev	*Dillenia pentagyna* Roxb.	
sandan	*Ougenia oojeinensis* (Roxb.) Hochreut	

Kusmi =The lac crop grown on *kusum*, the Indian lac tree (*Schleichera oleosa* (Lour.) Oken.), or on a few other suitable host trees from *kusum* brood or progeny.

Rangeeni =The lac crop derived from *palas*, the Flame-of-the-forest (*Butea monosperma* (Lamk.) Taubert; syn. *B. frondosa* Koenig ex Roxb.), jujube (*Zizyphus mauritiana* Lamk.; syn. *Z. jujuba* Lam. non Mill), etc.

Aghani =The rain crop of lac (June–July to January–February), grown on *kusum* tree, or from the progeny of *kusum* brood on other suitable tree.

Baisakhi =The summer crop of lac (October–November to June–July) from trees other than *kusum* using *Rangeeni* brood.

Katki =The rain crop of lac (June–July to October–November), grown on hosts other than *kusum* or from *Rangeeni* brood.

Jethwi =The hot-weather crop of lac (January–February to June–July) on *kusum* tree, or other trees using *kusum* brood.