INDIAN LAC RESEARCH INSTITUTE
NAMKUM, RANCHI, BIHAR, INDIA

Annual Report
1979 & 80

ICAR

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
NEW DELHI
1984

COMMITTEE FOR PROCESSING AND EDITING OF ANNUAL REPORT

1.	Dr. B. B. Khanna	Chairman
2.	Sri N. S. Chauhan (alternate Dr. C. P. Malhotra)	Member (Ento. Div.)
3.	Dr. S. K. Saha	Member (Ext. Div.)
4.	Dr. P. C. Gupta (alternate Sri A. K. Ghosh)	Member (Tech. Div.)
5.	Sri B. K. Purkayastha (alternate Dr. P. Kumar)	Member (Agro. Div.)
6.	Dr. S. C. Agarwal	Member-Secretary (Chem. Div.)

CONTENTS

	PAGE
1. DIRECTORS'S INTRODUCTION	1
2. PROGRESS OF RESEARCH	6
A. *Entomology Division*	6
(a) *Researches completed*	6
(b) *Researches on hand*	28
Physiological studies on lac insects and associated insects ...	28
Ecology of lac insect and associated insects	31
Control of enemies of lac insects	35
Genetics and breeding of lac insects	43
(c) *Researches contemplated*	47
(d) Operational Research Project	47
B. *Agronomy and Plant Genetics Division*	53
(a) *Researches completed*	53
(b) *Researches on hand*	54
Propagation and management of lac host plants	54
Genetics and breeding of lac host plants	62
(*c*) *Researches contemplated*	69
(*d*) Institute Plantation	69
(*e*) Mixed plantation scheme at Chandwa	70
C. *Chemistry Division*	70
(*a*) *Researches completed*	70
(*b*) *Researches on hand*	78
Chemistry of lac/constituents	78
Fine chemicals from lac	85
Modification of shellac/constituents and their utilization ...	86
Use of shellac and modified shellac in surface coatings ...	88
Use of lac for encapsulation and control release	89
Electrical properties of lac and modified lacs	90
Standardisation of lac/constituents	91
(*c*) *Researches contemplated*	92

D. *Technology Division* 92
(*a*) *Researches completed* 92
(*b*) *Researches on hand* 95
Improvement in the processing techniques 95
Rubber-shellac combinations 99
Use of lac in adhesives 100
(*c*) *Researches contemplated* 101

E. *Extension Division* 101
(*a*) *Researches completed* 101
(*b*) *Researches on hand* 101
Studies on AC deposition of shellac based paints 101
Development of shellac bond powder 102
Effect of storage on sticklac 102
(*c*) Sponsored research 103
(*d*) *Researches contemplated* 105

3. EXTENSION 106

4. PAPERS PUBLISHED 109

5. CONFERENCES AND SYMPOSIA 111

6. SUMMARY 112

7. METEOROLOGICAL REPORT 121

8. PERSONNEL 123

1. DIRECTOR'S INTRODUCTION

A brief historical introduction

The Indian Lac Research Institute, Ranchi which was set up in 1925 continued to function under the administrative control of the Indian Council of Agricultural Research, New Delhi w.e.f. April 1, 1966.

The Institute is located at Namkum, about nine kilometers east of Ranchi. Out of a total area of 49 ha, nearly 35 ha, are being used as plantation for cultivation experiments. Areas/trees have been taken on long term lease for outstation experiments.

Objectives

The objectives of the Institute are:

(i) To carry out research towards affecting improvements in the cultivation, processing and standardisation of lac and study its constitution and modifications so as to intensify lac production and extend its utilisation.

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

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

Organisational set-up

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

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

Research Highlights

Entomology

Among the notable results, mention may be made of the identification of *putri* (*Croton oblongifolius*) and *baryari* (*Desmodium pulchellum*) as new potential lac hosts for raising particularly the *baisakhi* and the *aghani* crops respectively.

Study of crosses of *rangeeni* and *kusmi* strains of lac insects has provided evidence of considerable hybrid vigour, the utilisation of which thus holds promise for improving lac productivity.

Further cytological studies of the Indian lac insect *kerria lacca* (Kerr) have confirmed a 'Lecanoid' system of chromosome behaviour.

Studies on the sex ratio in individual progenies of lac insects have shown the occasional occurrence of unisexual progenies of either sex and provided evidence of genetic variation in sex ratio and progeny size.

Agronomy and Plant Genetics

The combination of IBA+IAA (100 ppm) and propagation in June was found to be the best in establishing maximum number of rooted air layers in *kusum*.

Foliar spray of GA_3 (80 ppm) + urea (1%) on newly emerged sprouts of *kusum* after pruning gave the best results in regard to shoot length.

Chemistry Division

The studies on the suitability of shellac as a binder-cum-fuel for solid rocket propellants has shown that they burn smoothly, leave no ash and possess good mechanical properties except adequate flexibility.

Technology

Dewaxed lac prepared in aqueous medium is suitable for the production of water-soluble lac.

Library

The number of books and bound volumes of journals accessioned during the period was 602. This brought the total number of books and volumes of journals in the library to 17,417. Two hundred fifty periodicals were subscribed in addition to a few received in exchange or as gift. Some miscellaneous publications and reports were also received.

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

ICAR Regional Committee Meeting

The Third Meeting of the ICAR Regional Committee No. 4 for the sub-humid Sutlej Ganga alluvival Plains comprising Punjab, Delhi, Uttar Pradesh and Bihar was held at the Institute on April, 21 and 22, 1980 under the chairmanship of Dr. O. P. Gautam, Director General, Indian Council of Agricultural Research, New Delhi. Besides, several senior officials of ICAR, nearly 30 delegate members representing various state/central Govt. Agencies participated in the meeting. The Director General drew the attention of the members to the main objectives of the Regional Committee and emphasized that the most important objective of these meetings was to feed back the relevant research problems of the region and appreciation of the dissemination of new technology in the region. These meetings provide opportunity to assess the effectiveness of development assistance given to Agricultural Universities and other Institutions in the region. He also emphasised that research results should reach the poor and marginal farmers. Keeping in view the above objectives, deliberations were made by the participants

and decisions were taken. On this occasion, Dr. T. P. S. Teotia, Director of this Institute apprised the delegates about the importance of shellac and highlighted the allied problems of lac industry.

Honours and awards

Sri R. N. Majee, Scientist S-1 (Organic Chemistry), was awarded Ph.D. degree of Ranchi University, in 1979 for his work "Some aliphatic acids of lac".

Dr S. C. Agarwal Scientist S-2 (Organic Chemistry), was elected Fellow of Institution of Chemists (F.I.C.), Calcutta, in 1980.

Sri S. C. Srivastava Scientist S-1 (Plant breeding and Genetics), was elected Fellow of the Indian Society of Genetics and Plant breeding, in 1980.

Sri B. C. Srivastava Scientist S-1 (Organic Chemistry), was awarded Ph.D. degree of Ranchi University, in 1980 for his work "Studies on physico-chemical properties of lac for encapsulation".

Sri N. Prasad Scientist S-1 (Organic Chemistry), was awarded Ph.D. degree of Ranchi University, in 1980 for his work "Study on the constitution of lac resin".

Sri A. K. Sen, Scientist S-1 (Entomology) was awarded Ph.D. degree of Calcutta University, in 1980 for his work "Studies on the haemolymph of the last instar larvae of *Eublemma amabilis*, Moore in healthy and parasitised conditions".

Visitors

The Institute has always been a regular attraction to most visitors to Ranchi particularly Scientists and Technologists. During the period under report also, it received the usual complement of visitors including high officials, delegates, trainees from Institutions and other distinguished persons. Some of them are listed below:

1. Kumari Kamala Kumari, Dy. Minister (Agriculture), Govt. of India.
2. Dr O. P. Gautam, Director General, Indian Council of Agricultural Research.
3. Lt. General Jaswant Singh, PVSM, VSm, Vice-Chief of the Army Staff.
4. Dr N. S. Randhawa, Dy. Director General, Indian Council of Agricultural Research.
5. Dr V. R. Bhalerao, Dy. Director General, Indian Council of Agricultural Research.
6. Sri R. B. Mathur, Dy. Inspector General of Forests, New Delhi.
7. Sri S. S. Dhanoa, Secretary, Indian Council of Agricultural Research, New Delhi.
8. Sri N. J. Joshi, Dy. Inspector General of Forests, New Delhi.
9. Dr H. S. Dhuria, ADG(PLM), ICAR.
10. Dr L. M. Jaiswani, ADG(Food Crop), ICAR.
11. Dr S. T. Gaekwad, ADG (Soil), ICAR.
12. Dr J. P. Singh, ADG (Horticulture), ICAR.
13. Dr C. Prasad, ADG (Coordination), ICAR.
14. Dr K. S. Gill, Dean of Agriculture, Punjab Agriculture University.
15. Dr B. S. Pathak, Dean, Agriculture Engineering, Ludhiana.
16. Dr K. K. Jha, Vice-Chancellor, Rajendra Agriculture University.

17. Sri S. R. Rungte, Chief of Trading and Standards, Bihar State Agril., Marketing Board.
18. Dr G. B. Deodikar, Ex. Director, Central Bee Research Institute, Pune.
19. Dr J. Venkateshwarlu, ADG-cum-Project Director, Dry Farming A.I.C. R.P., Hyderabad.
20. Dr Kishan Singh, Director, Indian Instt. of Sugar Cane Research, Lucknow.
21. Dr R. V. P. Sinha, Project Coordinator, Fisheries, Cuttack.
22. Dr B. D. Patil. Director, Indian Grass land and Fodder Research Instt., Jhansi.
23. Dr S. N. S. Srivastava, Director, Potato Research Instt., Patna.
24. Dr Sudha Nagarkatti, Project Co-ordinator for Biological Control, Indian Instt. of Horticultural Research, Bangalore.
25. Dr K. Sambatsiri, Dept. of Entomology, Kasetsart University, Bangkok-9, Thailand.
26. Dr B. P. Khare, Head, Dept. of Entomology, G. B. Pant University of & Agriculture Tech., Pantnagar.
27. Sri A. K. Kwatra, Director, Fisheries, Chandigarh, Punjab.
28. Sri M. L. Khybri, Head of Division, Land and Water Instt., Dehradun.
29. Dr H. Prasad, Director, Instt. of Animal Health, Bihar.
30. Dr R. B. Sinha, Director of Horticulture, Bihar.
31. Sri M. Lakra, Ex-MLC, Ranchi.
32. Dr R. Tiwari, Prof. and Head (Hort), Rajendra Agriculture University.

Training and Advisory Services

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

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

Research Collaboration Overseas and with Other Institutions

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

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

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

Finance

The Institute is being wholly financed by the Indian Council of Agricultural Research. The revised budget estimates of the Institute for the years 1979-80 and 1980-81 amounted to Rs 30·00 and Rs 32·38 lakhs under non-plan and Rs 9·09 and 8·47 lakhs under plan respectively. The actual expenditure, however, was Rs 29·60 and Rs 30·87 lakhs under non-plan and Rs 5·59 and Rs 6·84 lakhs under plan respectively.

2. PROGRESS OF RESEARCH

A. ENTOMOLOGY DIVISION

(a) RESEARCHES COMPLETED

1.1 Lac Cultivation Studies

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

Bhalia has proved a good lac host for raising the rainy season crops (*katki* and *aghani*) but not for the summer crops (*baisakhi* and *jethwi*). Field studies were, therefore, taken up to examine the possibility of utilizing it for raising the *jethwi* crop also by varying the brood rate, and time and method of harvesting and with or without the application of urea.

The experiment was laid out on a split-plot design with the following main and sub-plot treatments:

Main-plot

Treatment	*Brood rate (g)/bush*
B_1	100
B_2	200
B_3	400

Sub-plot

Treatment	*Cultural practices*
T_1	Complete harvesting as *ari* in May.
T_2	Partial harvesting in June-July and complete in Jan.-Feb.
T_3	As in treatment T_2 with foliar spray of urea (1%) at weekly interval for one month after the appearance of new flush of leaves.
T_4	Complete harvesting in June-July.
T_5	As in T_4 with foliar spray of urea as in T_3.

The crop data set out in Table 1 show that the crop yields were rather poor under all the practices tried. Hence, none of these practices has proved useful for utilizing *bhalia* for raising the summer crop.

(R. S. Gokulpure and P. Sen)

TABLE 1 — CROP PERFORMANCE UNDER DIFFERENT CULTIVATION PRACTICES TRIED ON *bhalia* (*Moghania macrophylla*) DURING *jethwi* 1976-CUM-*aghani* 1975-76 TO *jethwi* 1978-CUM-*aghani* 1978-79 CROPS

Cultural practice	*Stick lac yield (kg)/crop ratio†			Mean
	Brood rate			
	B_1	B_2	B_3	
T_1	5·665	8·145	11·820	8·543
	1:0·83	1:0·68	1:0·64	1:0·71
T_2	6·630	7·886	7·155	7·223
	1:0·95	1:0·63	1:0·39	1:0·65
T_3	5·900	9·000	10·215	8·398
	1:0·85	1:6·73	1:0·55	1:0·71
T_4	5·775	8·045	10·455	8·091
	1:0·87	1:0·63	1:0·55	1:0·68
T_5	6·925	6·375	10·190	7·817
	1:1·02	1:0·51	1:0·53	1:0·68
Mean	6·179	7·906	9·967	
	1:0·90	1:0·63	1:0·53	

*Pooled yield data from 120 bushes under each treatment in the four crops.
†Crop ratio refers to brood used to yield in terms of stick lac.

1.1.3 Evolution of a schedule for rangeeni lac cultivation on *galwang* (*Albizzia lucida*) and *ber* (*Ziziphus mauritiana*) in alternation

Since *ber* is particularly suited for raising the rainy season crops (*katki* and *aghani*) and *galwang* for the summer crops (*baisakhi* and *jethwi*), a study was taken up to examine the possibility of improving *rangeeni* lac cultivation using these host species in alternation, each for raising the crop it is particularly suited for. The experiment was laid out on a split-plot design with the following main-plot and sub-plot treatments:

Main-plot

Treatment	*Brood rate* [Brood lac length : Inoculable shoot length (m)]
B_1	1 : 50
B_2	1 : 25
B_3	1 : 12·5

Sub-plot

Treatment	*Fertilizer application*
F_1	No treatment (control).
F_2	Soil application of 100 g each of superphosphate and urea and 30 g of muriate of potash per bush one month prior to crop inoculation.
F_3	Same as above except that urea is applied as foliar spray.

There were two bushes in each treatment and five replications. The crop performance was compared with that raised on the conventional *rangeeni* host, *palas* (*Butea monosperma*).

The pooled data for 5 *baisakhi* and 4 *katki* crops, furnished in Tables 2a and b, show that in general, the crops produced were not satisfactory when compared with those obtained from the conventional host, *palas* which resulted in crop ratios of 1:3·86 and 1:1·87 during the *baisakhi* and *katki* crops respectively.

Thus, the alternation of *galwang* and *ber* as tried here has not proved useful for improving *rangeeni* lac cultivation.

(P. Sen and R. S. Gokulpure)

TABLE 2a — CROP PERFORMANCE ON *galwang* DURING *baisakhi* 1974-75, 1975-76, 1976-77, 1978-79 AND 1979-80 USING *ber* BROODLAC

Fertilizer application	*Sticklac yield (kg)/crop ratio†			Mean
	Brood rate			
	B_1	B_2	B_3	
F_1	3·360 1 : 1·84	2·835 1 : 1·11	5·300 1 : 1·26	3·831 1 : 1·40
F_2	3·065 1 : 1·85	3·980 1 : 1·60	3·710 1 : 0·93	3·585 1 : 1·46
F_3	3·665 1 : 1·95	5·045 1 : 1·85	4·555 1 : 1·11	4·421 1 : 1·63
Mean	3·363 1 : 1·88	3·953 1 : 1·52	4·521 1 : 1·11	

*Pooled yield data from 50 bushes under each treatment in the five crops.
†Crop ratio refers to brood used to yield in terms of stick lac.

TABLE 2b — CROP PERFORMANCE ON *ber* BUSHES DURING *katki* 1975, 1977, 1978 AND 1979 USING *galwang* BROODLAC

Fertilizer application	*Sticklac yield (kg)/crop ratio†			Mean
	Brood rate			
	B_1	B_2	B_3	
F_1	3·630 1 : 1·85	2·585 1 : 0·98	3·735 1 : 0·86	3·316 1 : 1·23
F_2	2·570 1 : 1·93	3·725 1 : 1·33	3·905 1 : 0·81	3·733 1 : 1·36
F_3	2·626 1 : 1·48	3·280 1 : 1·07	3·659 1 : 0·84	3·188 1 : 1·13
Mean	2·942 1 : 1·75	3·197 1 : 1·13	3·766 1 : 0·84	

*Pooled yield data from 40 bushes under each treatment in the four crops.
†Crop ratio refers to brood used to yield in terms of sticklac.

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

With a view to finding out new potential lac hosts to supplement *rangeeni* and *kusmi* lac production, lac cultivation trials were initiated in 1974 on *putri* (*Croton oblongifolius*), rain tree (*Samanea saman*), *bara salpan* (*Moghania chappar*), *baryari* (*Deomodium pulchellum*), *gorai* (*Millettia extensa*), *Moghania bracteata* and *Grewia hirsuta*.

After the preliminary trials, *putri*, *baryari* and *gorai* were screened for further lac cultivation experiments to find out their potential as *rangeeni* and *kusmi* lac hosts. The data set out in Tables 3a, b and c show that *putri* holds promise as a lac host for raising the summer crops particularly the *baisakhi*, and *baryari* for the *aghani*. The crop results with *gorai* have not been very encouraging.

(R. S. Gokulpure, P. Sen and S. K. Saha)

TABLE 3a — CROP DATA FOR LAC CULTIVATION ON *putri* (*Croton oblongifolius*)

Crop	No. of plants used	Brood used (sticklac, kg)	Yield (sticklac, kg)	Brood used: Yield (sticklac)	Remarks
Baisakhi 1973-74	5	1·600	8·000	1:5·00	
do 1974-75	30	1·200	4·875	1:4·06	
do 1975-76	23	1·700	—	—	The crop was destroyed by forest fire
do 1976-77	16	2·050	—	—	No yield
do 1977-78	13	1·000	—	—	No yield
do 1978-79	23	0·900	2·000	1:2·22	
do 1979-80	25	0·800	—	—	No yield
Katki 1974	40	2·000	0·900	1:0·45	
do 1975	16	0·900	0·925	1:0·91	
do 1976	102	4·000	—	—	No yield
do 1977	15	1·800	1·220	1:0·67	
do 1978	25	1·450	0·180	1:0·13	
do 1979	55	2·200	0·450	1:0·24	
do 1980	12	0·550	0·500	1:0·90	
Jethwi 1974	18	1·800	—	—	The crop was destroyed by forest fire
do 1975	20	0·900	2·100	1:2·33	
do 1976	25	1·325	—	—	The crop was destroyed by forest fire
do 1977	25	2·370	2·360	1:0·99	
do 1978	25	2·100	3·900	1:1·85	
do 1979	3	1·000	—	—	No yield
do 1980	50	5·250	1·600	1:0·31	

1.3.2 Effect of density of population and age of lac insect on the incidence of the major predators in different lac crops on different lac host plants

The study was taken to determine whether there is any relationship between the density and age of *K. lacca* and the incidence of major lac predators.

The *rangeeni* and *kusmi* strain of *K. lacca* were reared on *palas* and *kusum* respectively and also on *bhalia* during the rainy season. The density of lac insects

TABLE 3b — CROP DATA FOR LAC CULTIVATION ON *Baryari* (*Desmodium pulchellum*)

Crop	No. of plants used	Brood used (sticklac, kg)	Yield (sticklac, kg)	Brood used: Yield (sticklac)	Remarks
Baisakhi 1976-77	50	0·210	1·320	1:6·28	
do 1977-78	80	1·000	—	—	No yield
do 1978-79	30	0·212	—	—	do
do 1979-80	30	0·150	—	—	do
Katki 1977	30	0·400	0·350	1:0·87	
do 1978	75	0·600	0·720	1:1·42	
do 1979	56	0·290	0·175	1:0·60	
Jethwi 1977	100	0·950	—	—	No yield
do 1978	50	0·450	—	—	do
do 1979	15	0·200	—	—	do
do 1980	50	0·735	—	—	do
Aghani 1977-78	43	0·600	—	—	Left for self inoculation
do 1978-79	15	0·150	0·225	1:1·50	
do 1979-80	5	0·450	1·000	1:2·22	
do 1974-75	20	1·250	—	—	No yield
do 1975-76	25	0·900	—	—	do
do 1976-77	25	1·500	—	—	do
do 1977-78	50	3·800	3·930	1:1·03	
do 1978-79	18	1·450	0·200	1:0·13	
do 1979-80	52	4·500	4·500	1:1·00	

TABLE 3c — CROP DATA FOR LAC CULTIVATION ON *Gorai* (*Millettia extensa*)

Crop	No. of plants used	Brood used (sticklac, kg)	Yield (sticklac, kg)	Brood used: Yield (sticklac)	Remarks
Baisakhi 1976-77	4	0·100	0·450	1:4·50	
do 1977-78	5	0·400	—	—	Poor crop left for self inoculation
do 1978-79	23	0·790	0·900	1:1·13	
do 1979-80	16	0·100	—	—	No yield
Katki 1977	5	0·060	—	—	No yield
do 1978	7	0·150	—	—	do
do 1979	25	0·350	0·200	1:0·57	
do 1980	16	0·450	0·100	1:0·22	
Jethwi 1977	34	0·750	—	—	Poor crop left for self inoculation
do 1978	25	0·950	2·250	1:2·25	
do 1979	25	0·600	—	—	No yield
do 1980	7	0·150	0·350	1:2·33	
Aghani 1977-78	34	0·650	—	—	No yield
do 1978-79	11	0·200	0·200	1:1·00	
do 1979-80	35	3·300	3·300	1:1·00	

was varied using different brood rates on two and five plants of tree of bushy species respectively. Four randomly selected branches on each *kusum* and *palas* tree and 5 on 5 *bhalia* bushes were covered with muslin sleeves from the time of inoculation till harvesting and each sleeved branch was provided with one or two pairs of *Eublemma amaiblis* and *Holcocera pulverea* moths for artificial infestation. The rest of the branches were inoculated and left uncovered for natural infestation which served as control. The predator numbers were compared between the treatments by collecting and caging 2 branches with induced infestation and 2 from natural infestation from each tree and for 5 *bhalia* bushes at the time of third moult at crop maturity.

The artificial or induced infestation by releasing the predators on the sleeved branches was discontinued due to non-availability of sufficient numbers of predators at the time of releases.

Thus the whole experiment was recast and planned according to new lay out. The new experimental unit comprised of one tree in *kusum* and *palas*, 3 bushes in *bhalia* with 6 replications of all the 4 treatments. The host plants after inoculation was left for natural infestation by the predators. Six randomly selected samples, each measuring 15 cm in length, were collected from each treatment at *phunki* removal and at sexual and crop maturity.

The first two samples were examined under stereoscopic binocular microscope for eggs and early larval stages of predators and third sample was first caged for about a month for emergence of adult moths and these were examined for dead larvae, pupae and adult moths on the caged twigs and in the debris in the cage.

The experiment was started in 1972 and concluded in 1979. During this period, 7 *baisakhi* and 7 *katki* crops on *palas*, 6 *jethwi* and 6 *aghani* crops on *kusum*, and 4 *katki* and 4 *aghani* crops on *bhalia* were raised.

The pooled data on the emergence of insects from various crops on different host species at the time of *phunki* removal and at sexual and crop maturity are presented in Table 4.

From the data it may be observed that heaviest infestation of *E. amabilis* and *H. pulverea* always occurred on heaviest inoculation in *baisakhi* and *katki* crops on *palas*, *jethwi* and *aghani* crops on *kusum* and in *katki* and *aghani* crops on *bhalia* at *phunki* removal and at sexual and crop maturity, except in case of *jethwi* crop on *kusum* at sexual maturity, the average number of *H. pulverea* was slightly less at 1/2 kg brood rate than 1/4 kg brood rate and at crop maturity the average number of both the major predators was maximum at 1/2 kg brood rate. In case of *aghani* crop on *kusum* at *phunki* removal, the average number of *E. amabilis* was not proportional to the increase in the rate of brood lac at 1 kg brood rate and *H. pulverea* at 1/2 kg and 1 kg brood rate.

In case of *baisakhi* crop, the average number of *E. amabilis* and *H. pulverea* at sexual maturity and the average number of *H. pulverea* at crop maturity and in *katki* crop, the average number of *E. amabilis* at crop maturity were not proportional to the increase brood rate on *palas* at 250 gm brood rate.

Barring some exceptions, the data on the whole shows that in general, the incidence of the predators increased with the increase in the density of lac insects in different crop seasons and on different lac host plants.

(B. P. Mehra, R. L. Tripathi and B. N. Sah)

TABLE 4 — INCIDENCE OF THE MAJOR PREDATORS (ALL STAGES) IN RELATION TO THE AGE AND DENSITY OF THE LAC INSECTS

Crop and period	Host	Rate of broodlac kg	At phunki removal		At third moult		At crop maturity	
			Eu-blemma amabilis	*Holco-cera pulverea*	*Eu-blemma amabilis*	*Holco-cera pulverea*	*Eu-blemma amabilis*	*Holco-cera pulverea*
			Av. 4 crops		Av. 6 crops		Av. 7 crops	
Baisakhi 1972-73 1978-79	*Palas*	0·125	33·0	2·0	33·3	6·0	145·9	81·3
		0·250	48·2	4·0	32·3	4·8	186·1	65·4
		0·500	64·5	8·5	43·8	9·8	200·5	108·7
		1·000	98·0	15·5	54·1	14·3	228·7	122·8
			Av. 4 crops		Av. 5 crops		Av. 6 crops	
Katki 1973, 74, 76 & 77	*Palas*	0·125	54·75	7·5	38·2	11·8	12·16	1·83
		0·250	79·00	15·75	60·2	20·2	11·16	2·00
		0·500	97·00	22·75	86·4	32·0	32·00	7·5
		1·000	141·00	26·75	147·2	47·6	45·00	12·6
			Av. 2 crops		Av. 3 crops		Av. 4 crops	
Katki 1973, 74, 76 & 77	*Bhalia*	0·025	40·0	3·0	32·3	5·6	3·0	1·5
		0·050	61·5	6·5	44·3	13·0	5·75	2·2
		0·100	91·0	17·0	87·3	20·3	18·25	4·75
		0·200	120·5	23·0	117·3	31·6	25·00	5·0
			Av. 3 crops		Av. 4 crops		Av. 5 crops	
Jethwi 1973-78	*Kusum*	0·250	50·3	2·6	37·2	8·0	24·0	23·8
		0·500	84·6	8·3	74·0	7·0	63·8	52·6
		1·000	101·6	9·3	105·3	9·2	52·4	28·8
		2·000	128·0	11·6	127·6	11·5	49·8	40·8
			Av. 4 crops		Av. 4 crops		Av. 5 crops	
Aghani 1973-74 1977-78	*Kusum*	0·250	88·75	22·0	43·25	2·75	6·8	4·8
		0·500	116·25	8·0	59·0	4·50	10·0	5·2
		1·000	108·0	46·75	69·5	12·0	14·6	7·0
		2·000	216·50	29·00	121 25	19·0	22·0	14·2
			Av. 3 crops		Av. 3 crops		Av. 4 crops	
Aghani 1973-74 1977-78	*Bhalia*	0·025	27·6	5·3	47·0	4·0	5·5	4.75
		0·050	39·3	7·0	76·0	8·0	9·5	5 75
		0·100	69·0	11·6	79·0	10·3	14·7	10·20
		0·200	97·0	30·0	124·3	24·0	16·2	16·25

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

The study was taken up to determine precisely the effect of the insecticidal control (developed earlier at the Institute) on lac insects and the associated fauna.

In *katki*, *jethwi* and *baisakhi* crops, only one combination spray of Thiodan® and Thuricide mixed in equal proportion (0·05% each) was given 4-5 weeks after crop inoculation in the former two crops and during February-March in the latter. In the *aghani* crop, two sprayings with (0·05%) Thiodan® 3-4 weeks after inoculation and the second with combination spray as above three weeks thereafter were given.

The lac insects culture for each crop was maintained on ten potted *bhalia* plants, five for the insecticidal spray and the remaining five for water spray which served as the control. The lac insects were studied for their survival, sex ratio, proportion of dimorphic males, rearing period, fecundity, resin secretion and resin dye-level.

Developmental period of lac insects was judged by observing the time of male and nymph emergence. Survival of the settled nymphs was observed in days after spraying and sex-ratio and wing dimorphism recorded at male emergence. Fecundity and resin secretion per cell and resin dye-level were observed at crop maturity. Population of associated insect fauna was found by caging mature lac at the time of harvesting.

Average of all the four lac crops for 4-5 seasons is given in Table 5 from which it may be observed that in *katki* crops, the average developmental period of females, average percentage of alate male and average fecundity of female lac insect were 33, 54 and 33 percent respectively higher in treated than the control.

In *jethwi* crops, fecundity was 19 percent higher in treated than control but other attributes are nearly the same.

In *aghani* crops, percentage of alate male was 0·65 more in control than the treated whereas fecundity was 46 percent higher in treated than control.

From the above, it is concluded that the integrated control schedule of lac predators did not adversely affect any of the economic attributes of *K. lacca* rather it has resulted in increase in fecundity, indicating that the insecticidal sprays have caused some hormoligatory effects beneficial to the lac insect in this regard.

(B. N. Sah, B. P. Mehra, D. C. Srivastava and R. L. Tripathi)

1.4.1 Field trials for evolving integrated control sechedules against the lac predators

The project was taken up with the object of integrating the various control measures such as mechanical, chemical and microbial developed earlier individually in time and space against the lac predators, so as to work out the most effective control schedules in appropriate sequential and compatible manner for each of the four lac crops.

Following control measures were taken up for integration:

W — Use of 60-mesh synthetic-netting containers for inoculation (Mechanical measure)

E — A 0·05 percent spray of Thiodan® (endosulfan) (Chemical measure)

B — A 0·05 percent spray of commercial preparation of *Bacillus thuringiensis* (Microbial measure)

C — A 0·05 per cent spray of mixture of E and B, in equal proportions.

N No treatment

A — Water spray

The sequence of the treatments in a particular crop is indicated by the order of the symbol used. Where the harvest was made after raising two successive crops

TABLE 5 — EFFECT OF INSECTICIDAL CONTROL OF PREDATORS ON THE VITAL AND ECONOMIC ATTRIBUTES OF THE LAC INSECT

Crop		Treatment	Effect on lac insect								
			Average % survival after		Average rearing period (days)		Average % males		Average weight (mg)	Average fecundity	Average dye level
			First spray	Second spray	Males	Females	Alate	Pterous			
Baisakhi 1974-75 1977-78 1978-79 1979-80	=4	Insecticide spray	78·02	×	125·68	254·83	5·03	19·88	12·97	297·40	0·0192
		Water spray	78·97	×	125·65	255·94	4·78	19·14	11·09	226·12	0·0197
Katki 1975, 1977, 1978, 1979	=4	Insecticide spray	69·50	×	48·61	81·67	0·58	19·21	6·46	224·81	0·0142
		Water spray	75·32	×	50·22	61·00	0·09	21·39	5·70	168·76	0·0149
Jethwi 1975, 1977, 1979	=5	Insecticide spray	73·67	×	67·34	158·37	7·44	16·57	11·07	373·08	0·01555
		Water spray	68·46	×	67·66	159·47	5·12	16·23	10·15	312·02	0·0143
Aghani 1975-76 1976-77 1977-78 1978-79 1979-80	=4	Insecticide spray	58·27	61·18	63·01	217·96	0·34	27·48	15·48	284·75	0·0124
		Water spray	64·26	57·64	63·55	216·62	0·99	21·25	13·23	194·67	0·0124

and the treatments remained the same in each, the symbolic representation of the schedule is shown as multiplied by 2. Thus, $W(EE)_2$ indicates that the crop was raised with the use of mechanical measure and sprayed twice with Thiodan® in each crop.

The efficacy of the schedule was judged on the basis of yield and predator incidence. For the latter purpose, lac samples were collected at the time of crop maturity and caged in the parasite cages for noting the emergence of predators therefrom.

(I) *Aghani crop on the host plant, namely, bhalia (Moghania macrophylla) at Taimara Field area* — The experiment was laid out in a randomized block design with the control plot separated from the others by a distance of about 150 metres. The control schedules tried were WEB, WC, WB, WE, W and N (a no treatment control). Each schedule was tried in a unit of 10 bushes with 4 replications. The first spray was given three weeks after the crop inoculation and the second, when provided, three weeks thereafter. The data on yield and predator incidence on an average of three *aghani* crops (1972-75) are shown in Table 6a. It may be seen that overall performance in respect of yield and predator suppression was in the order of WEB>WE>WC>WB>W.

TABLE 6a — DATA ON YIELD AND SUPPRESSION OF PREDATORS ON AGHANI CROPS ON *Moghania macrophylla* AT TAIMARA (AVERAGE FOR 3 SEASONS 1972-1975)

Treatment	Inoculation (kg/bush)		Yield (kg/bush)						
			Lac sticks			Scraped lac from			
	Lac sticks	*Phunki* scraped lac	Brood lac	Rejected lac	Total	Brood lac	Rejected lac	Total	Percent suppression of predators
W	1·000	0·394	0·993	2·177	3·170	0·214	0·138	0·352	45·9
WB	1·000	0·411	0·968	1·927	2·895	0·210	0·140	0·350	71·6
WC	1·000	0·399	1·191	2·266	3·457	0·281	0·149	0·430	64·8
WE	1·000	0·405	1·319	1·695	3·014	0·316	0·151	0·467	68·6
WEB	1·000	0·388	1·256	1·579	2·835	0·330	0·133	0·463	72·9
N	1·000	0·238	0·431	1·892	2·323	0·092	0·107	0·199	—

(II) *Baisakhi-cum-katki crops on palas at Lota farm* (1973-74 *to* 1975-76) — The trials were carried out with fourteen control schedules in 1973-74 and 15 schedules in 1974-75 and 1975-76 as shown in Table 6 b and Table 17a of A.R. 1974-76. Each treatment was carried out on crop raised on one tree with four replications. The spray schedules for the above crops were as follows:

Year	*Sprayings (weeks after inoculation)*
1973-74	18, 24, 42
1974-75	19, 25, 39 and 42
1975-76	19, 25, 40 and 45

The crop data for 1973-74 is presented in Table and of the averages for 1974-75 and 1975-76 in Table 6b. It may be seen that 3 or 4 sprays of Thiodan® alone spread over both the crops, for the three consecutive years, have given best overall performance in respect of brood and stick lac yield as also the suppresson of both the lac predators. Other treatments were also effective in varying degrees.

III. *Jethwi* 1973-*cum-aghani* 1973-74 *crop on kusum at the Institute plantation* — Fifteen control schedules were tried. Each treatment was carried out on crop raised on one kusum tree replicated twice. The sprays were given 9, 18, 31 and 34 weeks after inoculation. The data have been presented in Table 14 (A.R. 1974-76). It may be seen that overall performance in respect of yield and predators suppression was in the order of WCE>WEB>WC>WCC = WEE= WBB = WE.

(IV) *Aghani* 1973-74 *crop on khair at the Institute plantation* — Fourteen schedules were tried, each on crop raised in one khair tree. Sprays were given 7 and 11 weeks after inoculation. The results have been given in Table 15 (A.R. 1974-76). The crop failed about completely under the control schedules E and BC due to some unknown reasons but other control schedules resulted in yield improvements and predators suppression as compared to control. The crop in general was however, poor. Overall performance in respect of yield and predator suppression was in the order of CC>CB>EC>BB>CE.

(V) *Jethwi* 1973 *crop on kusum at the Institute plantation* — Fifteen control schedules were tried. First spray was given 10 weeks after inoculation and second, where provided, 9 weeks thereafter. The data is provided in Table 9 (A.R. 1974-76).

It may be seen that overall performance in respect of yield and predator suppression was in the order of WC>WEC>WBC>WCB. From the results it can also be concluded that where a combination spray is involved superior results have been obtained.

(VI) *Baisakhi-cum-katki* 1977-78 *and* 1978-79 *crops on palas at Lota* — Sixteen control schedules (including two controls), with one *palas* tree under each, replicated five times were tried. Only one spray was given in the *baisakhi* crop whereas either one or two sprayings were given during *katki* season.

From the data presented in Table 6c, it may be seen that overall performance with respect to yield and predator suppression was in the order of 0·075% Thiodan® 0·10 Thiodan® 0·05% Thiodan® 0·1% combination of Thiodan® Thuricide® +0·1% Cryolote. The study has revealed that the concentration of Thiodan® can profitably be increased up to 0·075 percent.

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

1.4.2 Studies on evolving cultural control for the enemies of lac insect

The project aims at cultural control of enemies of the lac insect, particularly the predator, *E. amabilis* by (i) Trap cropping i.e., varying the brood rate at inoculation and cropping a high brood rate crop as *ari* (ii) phenological manoeuvering i.e., varying the time of inoculation and thereby asynchronising the pest cycle vis-a-vis that of the lac insect (iii) improving upon the previously developed brass wire-netting inoculation containers by those from some cheaper material and (iv) exposing lac sticks to sunshine, the first two, for obviating the damage caused by pests and the others for the prevention of their carry over to the succeeding crop and damage during storage.

TABLE 6b—EFFECT OF VARIOUS CONTROL SCHEDULES ON THE LAC CROP YIELDS AND PREDATOR POPULATION IN *baisakhi*-CUM-*katki* CROPS 1974-75 AND 1975-76 (AVERAGE) ON *palas* AT LOTA FARM

Treatment	Average lac yield/tree (kg)						Average number of predators per 100 g sticklac			Percent suppression of the predator
	Lac stick			Stick lac			*E.a.*	*H.p.*	Total	
	Brood lac	Rejected lac	Total	Brood lac	Rejected lac	Total				
N	1·821	0·800	2·621	0·251	0·082	0·333	17·50	20·93	38·43	—
$(A)_2$	1·225	1·762	2·987	0·156	0·188	0·344	11·32	15·13	26·45	31·19
$(AA)_2$	2·237	3·058	5·295	0·356	0·146	0·512	20·00	11·84	31·84	17·12
$(E)_2$	2·562	1·875	4·437	0·380	0·101	0·481	10·73	13·54	24·27	36·91
$(EE)_2$	2·912	2·400	5·312	0·472	0·177	0·649	11·61	8·10	19·71	49·23
$(EB)_2$	2·350	1·600	3·950	0·344	0·092	0·436	20·23	12·78	33·01	14·10
$(EC)_2$	2·350	1·825	4·175	0·383	0·122	0·505	12·56	9·87	22·43	41·63
$(B)_2$	2·400	2·087	4·487	0·361	0·136	0·497	11·76	13·89	25·65	33·27
$(BB)_2$	3·400	3·137	6·537	0·546	0·225	0·771	11·04	16·68	27·72	28·12
$(BC)_2$	3·537	2·162	5·699	0·586	0·113	0·699	15·50	11·86	27·36	29·59
$(BE)_2$	2·612	1·695	4·307	0·267	0·090	0·357	14·52	12·92	27·44	29·14
$(C)_2$	1·837	2·712	4·549	0·332	0·163	0·495	10·59	12·41	23·00	40·15
$(CC)_2$	2·650	1·782	4·432	0·478	0·191	0·669	6·66	10·11	16·77	56·33
$(CB)_2$	2·537	2·175	4·712	0·453	0·209	0·662	11·47	11·48	22·95	40·28
$(CE)_2$	2·712	2·012	4·724	0·430	0·123	0·553	11·45	9·76	21·31	44·55

TABLE 6c — EFFECT OF VARIOUS CONTROL SCHEDULES ON THE LAC CROP YIELD AND PREDATOR POPULATION IN *baisakhi* 1977-78-CUM-*katki* 1978 AND *baisakhi* 1978-79-CUM-*katki* 1979 CROPS (AVERAGE) ON *palas* AT LOTA FARM

Insecticide	Concentration	No. of sprays	Average lac yield/tree (kg)						Average no. of predators per 100 g stick lac during		
			Lac stick			Stick lac					
			Brood lac	Rejected lac	Total	Brood lac	Rejected lac	Total	*Eublemma amabilis*	*Holcocera pulverea*	Total
Endosulfan	0·05	2/3	0·833	1·020	1·866	0·138	0·116	0·253	23·52	9·04	32·57
Endosulfan	0·075	2/3	1·013	1·666	2·568	0·188	0·142	0·330	13·28	8·76	22·04
Endosulfan	0·1	2/3	1·116	1·241	2·358	0·195	0·092	0·288	12·37	10·94	23·32
Combination	0·05	2/3	0·645	1·379	2·025	0·103	0·113	0·217	26·16	15·39	41·56
Combination	0·1	2/3	0·746	1·268	2·015	0·163	0·111	0·274	22·49	12·39	34·89
Cryolite	0·1	2/3	0·789	1·458	2·247	0·123	0·119	0·242	10·51	12·39	22·72
Control	—	2/3	0·520	0·806	1·326	0·076	0·056	0·132	44·67	24·08	68·75

Sub-project No. 1 — *Trap cropping*

Three relative spatial arrangements of the main and trap crop were tested against control i.e., (i) a bordering strip of trap crop all round the main crop (ii) alternate strips of main and trap crop (iii) group of trees bearing trap crop amongst the main crop trees (iv) control light (no trap crop) (v) control heavy (trap crop only). The experiment was laid out in a randomised block design with the above five treatments, four replications and 50 trees (25 heavy and 25 light) all told 1000 trees.

Trap crop was inoculated @ 1·00 kg/tree during October-November and resulting crop was harvested during April/May whereas main crop was inoculated 200 g/tree during Oct.-Nov. left for self inoculation during June/July and harvested completely in Oct./Nov. next.

Incidence of predators and the yield data for the period from 1973 to 1976 has been summarized in Table 7a from which the following conclusions can be drawn:

1. The predator, *E. amabilis* has initially been attracted for oviposition in all the spatial designs tested, the effect was more marked in case of strips of trap crop, alternated with those of the main crop.

2. The trapping of both the predators at the time of sexual maturity during the *baisakhi* crop was more marked in the case of groups treatment.

3. It could not, however, maintain the above trend till the crop maturity in the following *katki* crop, when the incidence of predators abruptly increased resulting in unexpected lower yields indicating that the effect of the treatment had then been lost and thus the method has to be supported/integrated with say a spray of the insecticide, Thiodan®.

4. On the whole the ' Border ' and the ' Strip ' treatments proved more effective in trapping the predators, maintaining the trend till crop maturity and also giving comparatively higher yields.

5. All the above spatial arrangements have resulted in trapping of the predators and giving higher yields as compared to control, confirming earlier observations of the density dependent oviposition behaviour of the predator.

Sub-project No. 2 — *Control by varying the date of inoculation*

Attempts were made to procure broodlac from Delhi and Jodhpur which could be received only once. However, broodlac from various localities which showed differences in larval emergence for about a week to 10 days, from within Bihar namely, Namkum, Chandwa, Paini Parmalchak and Kundri was obtained and inoculated at Kundri using synthetic-netting containers during the months of October November @ 250 g/tree, under a randomized block design with five replications and five trees under each treatment i.e., all total 100 trees. These were allowed a self colonization during the months of June/July of the succeeding year and completely harvested during following October/November. Obserervations on the incidence of predators were taken during the month of February to April i.e., at sexual maturity and October/November i.e., at the time of crop maturity. For this purpose, during February/April one metre lac bearing twig was collected from each tree and scored for the number of predators (all stages) and at the time of maturity in Octoober/November, lac samples were caged for scoring the number of adult predators emerging therefrom and calculated per 100 g sticklac.

Crop inoculations were varied from the second week of October to second week of November. The predator incidence and the yield data for the period from 1974 to 1978 is summarized in Table 7b and Figs. 1 and 2.

TABLE 7a — EFFECT OF THREE SPATIAL DESIGNS OF TRAP CROPPING ON LAC CROP YIELD AND PREDATOR POPULATION (AVERAGE FOR THREE YEARS i.e. FROM 1972-73 TO 1974-75)

Treatmcnt	Broodlac used/ tree (kg)		Average lac yield/tree (kg)								Average number of predators					
			Lac stick				Sticklac				per metre lac stick (March-April)			per 100 g sticklac (Oct.-Nov.)		
	Lac stick	Stick lac	Brood lac	Re-jected lac	Ari lac	Total	Brood lac	Re-jected lac	Ari lac	Total	*E.a.*	*H.p.*	*E.a.*	*E.a.*	*H.p.*	Total
TRAP CROP																
Border	1·00	0·324	—	—	3·660	3·660	—	—	0·797	0·797	0·74	2·06	2·80	—	—	—
Alternate strips	1·00	0·319	—	—	3·362	3·362	—	—	0·754	0·754	0·62	1·58	2·20	—	—	—
Interspersed	1·00	0·321	—	—	3·322	3·322	—	—	0·745	0·745	0·47	1·47	1·94	—	—	—
MAIN CROP																
Border	0·200	0·061	0·642	0·355	—	0·997	0·131	0·043	—	0·174	0·28	1·14	1·42	21·63	71·93	93·56
Alternate strips	0·200	0·061	0·612	0·357	—	0·969	0·129	0·038	—	0·167	0·14	1·42	1·56	23·08	60·27	83·35
Interspersed	0·200	0·060	0·577	0·333	—	0·910	0·116	0·036	—	0·152	0·17	1·06	1·23	30·63	76·75	107·38
Control	0·200	0·062	0·460	0·313	—	0·773	0·092	0·035	—	0·127	0·45	1·70	2·15	39·66	83·98	123·64

E.a.— *Eublemma amabilis.*
H.p.— *Holcocera pulverea.*

TABLE 7b — EFFECT OF VARYING THE DATES OF INOCULATION ON THE LAC CROP YIELD AND THE INCIDENCE OF LAC PREDATORS (AVERAGE FOR 5 YEARS i.e. FROM 1972-73 TO 1976-77)

Inoculation period		Brood used/ tree (kg)		Average lac yield/tree (kg)						Incidence of predators					
				Lac stick			Stick lac			No. of predators/metre lac stick (in March-April)			No. of predators/100 g stick lac (in Oct.-Nov.)		
		Lac stick	Stick lac	Brood lac	Re-jected lac	Total	Brood lac	Re-jected lac	Total	*E.a.*	*H.p.*	Total	*E.a.*	*H.p.*	Total
	II	250	54	1·181	1·039	2·220	0·214	0·101	0·315	4·70	3·95	8·65	20·48	17·42	37·90
Oct.	III	250	47	1·190	1·327	2·517	0·220	0·349	0·569	2·455	5·845	8·30	44·93	48·86	93·80
	IV	250	54	1·551	1·602	3·153	0·292	0·142	0·435	3·03	4·02	7·06	22·34	25·06	47·40
Nov.	I	250	57	1·398	1·287	2·686	0·260	0·092	0·352	1·88	4·67	6·56	29·73	34·69	64·43
	II	250	55	1·754	0·846	2·568	0·356	0·078	0·434	2·52	3·28	5·80	13·24	24·41	37·65

E.a.— Eublemma amabilis.
H..p— Holcocera pulverea.

CULTURAL CONTROL OF THE ENEMIES OF LAC INSECTS
BY
VARYING DATES OF INOCULATION

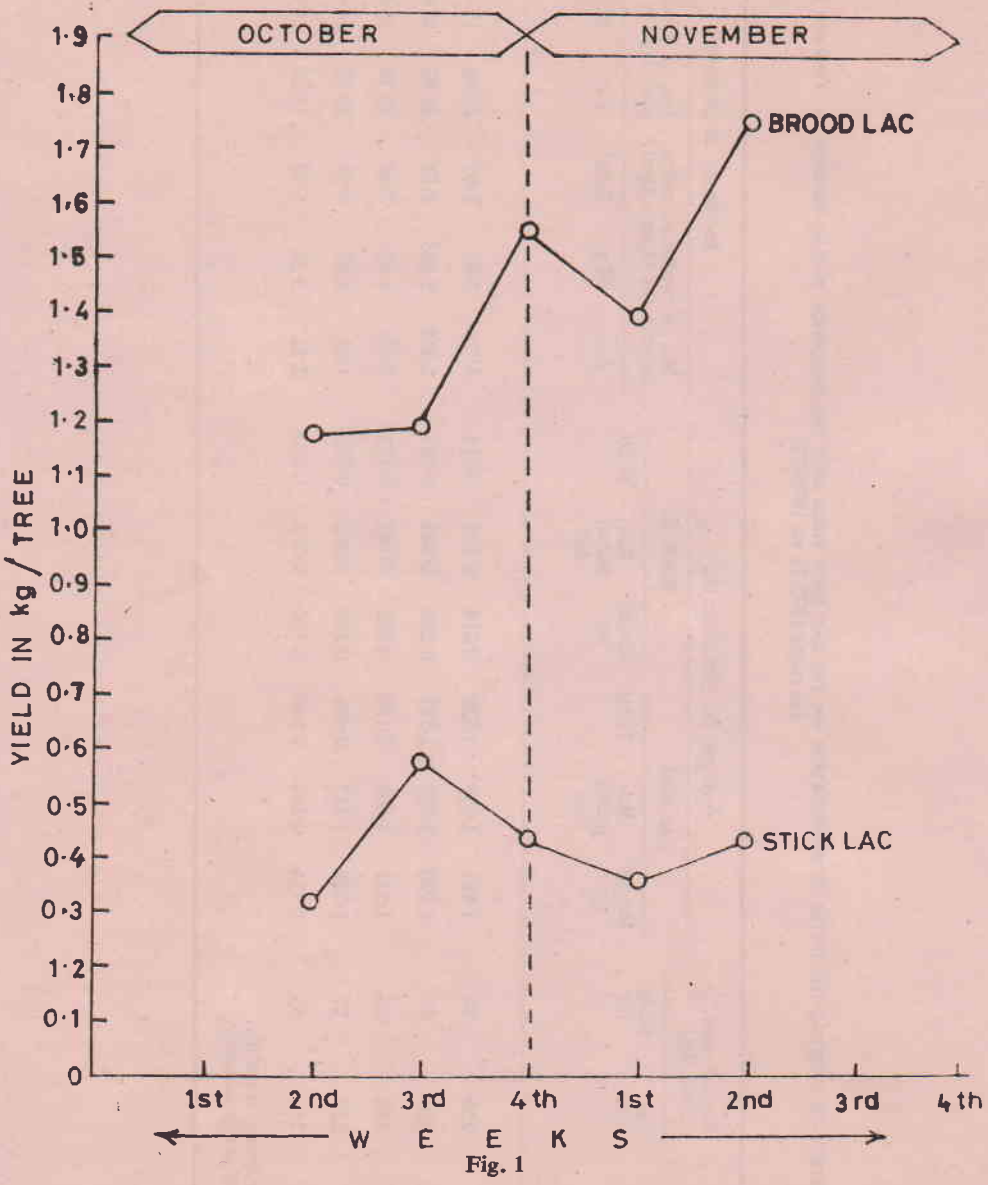

Fig. 1

It may be seen that the incidence of both the predators i.e., *E. amabilis* and *H. pulverea* recorded at the time of sexual maturity i.e. February/April, exhibits a declining trend with the advancement of inoculation dates beyond October and corresponding increases in the yield of sticklac were also obtained.

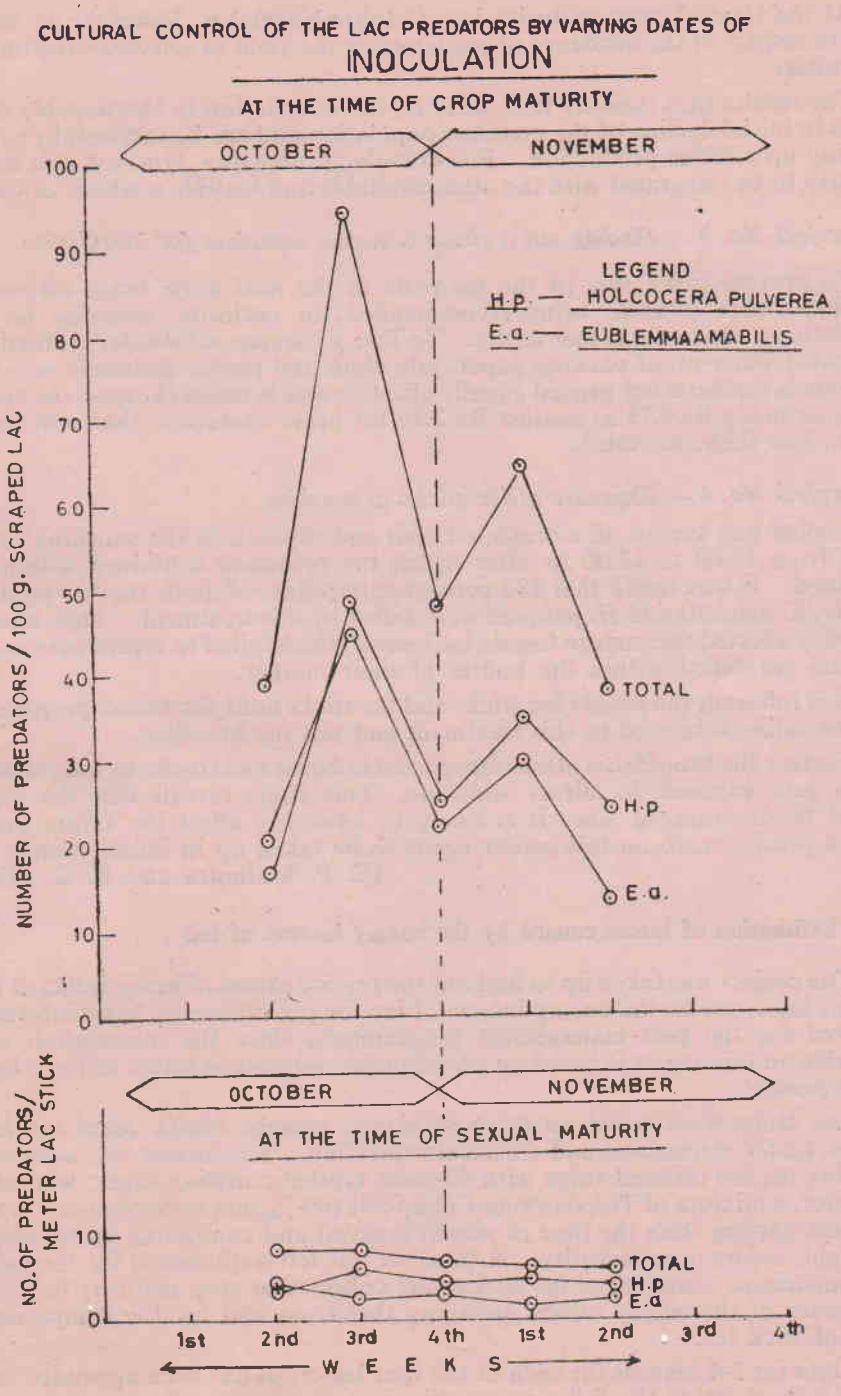
CULTURAL CONTROL OF THE LAC PREDATORS BY VARYING DATES OF INOCULATION
AT THE TIME OF CROP MATURITY
OCTOBER
NOVEMBER
LEGEND
H.p. — HOLCOCERA PULVEREA
E.a. — EUBLEMMAAMABILIS
NUMBER OF PREDATORS / 100 g. SCRAPED LAC
100
90
80
70
60
50
40
30
20
10
0
TOTAL
H.p
E.a.
OCTOBER
NOVEMBER
AT THE TIME OF SEXUAL MATURITY
NO. OF PREDATORS/ METER LAC STICK
10
0
TOTAL
H.p
E.a
1st
2nd
3rd
4th
1st
2nd
3rd
4th
W E E K S

Fig. 2

At the time of crop maturity i.e., October-November, however, no definite trend in respect of the incidence of predators or the yield of selected broodlac was discernible.

The results thus indicate that delaying the inoculation to the possible extent, results in initial decline of the predator population and can be successfully used for stepping up sticklac production. For broodlac production, however, this method will have to be integrated with the other available and feasible methods of control.

Sub-project No. 3 — *Finding out a cheap broodlac container for inoculation*

To prevent carry over of the lac pests to the next crop, brass wire-netting containers were hitherto being recommended for enclosing broodlac for crop inoculations, which are rather costly. To find a cheaper substitute, synthetic net, perforated water-proof packing paper, jute cloth and plastic materials were tried. Sixty-mesh synthetic net proved equally effective and is much cheaper, the cost per container being Rs 0.75 as against Rs 2.50 for brass container, thus reducing the cost to less than one third.

Sub-project No. 4 — *Exposure of lac sticks to sunshine*

Broodlac was spread on a cemented floor and exposed to the sunshine for two hours from 10.00 to 12.00 hr after which the predators contained within were examined. It was found that 100 percent caterpillars of both the lac predators, namely, *E. amabilis* and *H. pulverea* were killed by this treatment. This, however, adversely affected the mature female lac insects which failed to reproduce since the crawlers got killed within the bodies of their mother.

It is inferred, the *phunki* lac sticks and lac sticks unfit for brood purposes can only be safely subjected to this treatment and not the broodlac.

Further the broodlac is often transported in buses and trucks to long distances which gets exposed to direct sunshine. This study reveals that the practice should be discouraged since it is likely to adversely affect the future progeny though precise work on this aspect needs to be taken up in future studies.

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

1.4.7 Estimation of losses caused by the enemy insects of lac

The project was taken up to find out the precise extent of losses inflicted to the various lac crops by the enemy insects of lac for providing the basic information required for the pest management programmes, since the information so far available on this aspect is based on guesstimates only and is stated to be as high as 50-60 percent.

Lac crops were raised on the host plants, namely, *bhalia*, *palas* and *kusum* bushes, under mechanical and chemical protection. The former was achieved by covering the lac infested twigs with 60-mesh synthetic netting cages; whereas for the latter, a mixture of Thiodan® and Thuricide (0·1 %, was sprayed once in a week/ ten days starting from the time of *phunki* removal and continuing up till about a fortnight, before crop maturity. A third set was left unprotected for the purpose of comparison. Samples of lac sticks were collected at crop maturity to note the emergence of the enemy insects emerging therefrom and for the comparison of yield of stick lac.

Data for 3-4 seasons for each of the four lac crops has been appended in the Table 8 from which the following conclusions can be drawn.

TABLE 8 — ESTIMATION OF LOSSES CAUSED BY THE ENEMY INSECTS OF THE LAC INSECT DURING VARIOUS CROP SEASONS (1976-80)

Crop	Period (No. of seasons)	Host plant	Treat-ment	No. of sprays/ crop season	Total no. of samples	Total length of samples	Average yield/ 100 cm		Percentage of reductoin of enemy insects				Avoidable loss of sticklac (%)
							Lac stick	Sticklac	*E.a.*	*H.p.*	Total predators	Harmful parasites	
Katki	1977-80 (Four)	*Bhalia*	A	9-12	450	13302	121·27	41·58	100	100	100	100	71·8
			B		450		91·42	27·97	75·4	66·8	72·10	41·879	58·2
			C		450		81·75	11·71	—	—	—	—	—
Aghani	1976-80 (Three)	*Bhalia/ kusum* bush	A	14-16	361	9022	162·5	48·26	100	100	100	100	65·9
			B		361		109·9	28·86	72·7	76·7	73·0	46·65	40·9
			C		361		70·8	16·44	86·6	—	—	—	—
Baisakhi	1977-80 (Three)	*Bhalia/ palas* bush	A	15-18	366	13576	98·02	15·26	100	100	100	100	38·9
			B		366		75·4	13·05	60·9	50·7	55·35	44·85	28·6
			C		366		55·79	9·31	—	—	—	—	—
Jethwi	1977-80 (Three	*Kusum* bush	A	12-15	500	17300	115·03	34·08	100	100	100	100	20·4
			B		500		103·09	31·95	62·6	63·9	62·93	22·68	14·2
			C		500		91·34	27·11	—	—	—	—	—

A = Mechanical protection.
B = Chemical protection.
C = Control.

E.a.— *Eublemma amabilis.*
H.p.— *Holcocera pulverea.*

(i) Avoidable loss of sticklac by providing mechanical/chemical protection has actually been worked out on an average to be 71·8/58·2, 65·9/40·9; 38·9/28·6 and 20·4/14·2 percent respectively for the *katki*, *aghani*, *baisakhi* and *jethwi* crops. An empirical evidence has thus been provided for the first time as to the extent of losses attributable to the inimical insects, from which it can be deduced that the crop protection measures are apparently obligatory for winter and rainy season crops i.e., *katki* and *aghani*, whereas for the *baisakhi* crop, the measures be adopted after appropriate scouting and these may perhaps be unwarranted for the *jethwi* crop since the losses appear to be below the economic threshold level.

(ii) Mechanical protection technique has given better results whereas in case of chemical protection even after raising the crop under an insecticidal umbrella, only a partial control of the inimical insect fauna has been achieved, which shows that there is further scope of improving upon the evolved pest control technology since the percent avoidable loss in yield of sticklac in the latter has fallen short by 13·6, 25·0, 10·3 and 6·2 percent in the *katki*, *aghani*, *baisakhi* and *jethwi* crops respectively, from that obtained under the mechanical protection.

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

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

Though morphologically indistinguishable, the so-called *rangeeni* and *kusmi* strains of the common Indian lac insect *Kerria lacca* (Kerr) differ distinctly in their rearing period, resin secretion and resin quality as judged by the dye-level. Studies were, therefore, taken up to determine the genetic behaviour of these strain differences.

Rearing period

The *rangeeni* and *kusmi* strains are both bivoltine and their rainy season generation commences at more or less the same time i.e, in June-July. The *rangeeni* completes the cycle in about four months and the *kusmi* in about six months.

Thus the *rangeeni* and *kusmi* strains and their F_1 and F_2 hybrid progenies were reared in the rainy season to study their rearing period. It will be seen from Table 9a that, although the rearing period difference studied here is genetic, the F_1 and F_2 results have failed to provide a clear picture of the genetic behaviour of this difference.

Resin secretion

The females of a *rangeeni* stock originating from Palamau (Bihar) were mated to the males of a local *kusmi* stock during the rainy season. Since the time of larviposition of the *rangeeni* and *kusmi* differs much, the F_1 and F_2 hybrid progenies could be reared only along with those of the maternal parent stock.

Table 9b shows that the F_1 hybrid females secreted much more resin (43·7%) than those of the maternal parent stock even though the rearing period of the former has been shorter (18%). The F_2 females also secreted more resin (22%) than those of the maternal parent stock. But the hybrid superiority of the F_1 females was reduced by about half in the F_2 generation as expected.

Resin dye-level

The *kusmi* insects are known to produce resin which contains about half as much dye as found in the *rangeeni* resin. The F_1 hybrid females of the reciprocal crosses of a local *rangeeni* stock and a *kusmi* stock originating from Madhya Pradesh were reared along with those of the parental stocks during the rainy season

TABLE 9a — DATA SHOWING THE REARING PERIOD OF THE RAINY SEASON GENERATION OF THE *rangeeni* AND *kusmi* STRAINS OF *K. lacca* AND THEIR CROSSES

Sl No.	Mother	Father	Daughters			Remarks
			No. tested	Rearing period (days) Range	Mean	
			EXPERIMENT I			
1	*Rangeeni*	*Rangeeni*	95	103-107	105·9	
2	*Kusmi*	*Kusmi*	83	180-224	193·1	
3	*Rangeeni*	*Kusmi*	48	105-122	114·0	
4	*Kusmi*	*Rangeeni*	37	106-266	125·6	Distributed in two distinct groups of 34 *rangeeni* type and 3 *kusmi* type
5	F_1 from the cross in Sl No. 3	F_1 from the cross in Sl. No. 3	109	103-125	112·1	
6	F_1 from the cross in Sl No. 4	F_1 from the cross in Sl. No. 4	46	104-249	115·9	Distributed in two distinct groups of 44 *rangeeni* type and 2 *kusmi* type
			EXPERIMENT II			
1	*Rangeeni* (Kundri)	*Rangeeni* (Kundri)	130	100-130	113·1	
2	*Rangeeni* (Jodhpur)	*Rangeeni* (Jodhpur)	30	110-130	118·3	
3	*Kusmi* (M.P.)	*Kusmi* (M.P.)	25	130-150	140·8	
4	*Kusmi* (Ranchi)	*Kusmi* (Ranchi)	103	210-230	219·5	
5	*Rangeeni* (Kundri)	*Kusmi* (M.P.)	13	120-250	196·8	Distributed in 3 distinct groups of 4 *rangeeni* type, 8 *kusmi* type and 1 intermediate
6	*Kusmi* (M.P.)	*Rangeeni* (Kundri)	28	110-190	122·5	Distributed in 2 distinct groups of 26 *rangeeni* type and 2 *kusmi* type
7	F_1 from the cross of Rengeeni (Jodhpur X *Kusmi* ♀ (Ranchi) ♀	F_1 from the cross of Rangeeni (Jodhpur) X *Kusmi* ♂ (Ranchi) ♂	73	120-250	131·0	Distributed in 3 disdint groups of 63 *rangeeni* type 3 *kusmi* type and 7 intermediate
8	F_1 from the cross of *Kusmi* (Ranchi) ♀ X Rangeeni (Jodhpur) ♀	F_1 from the cross of *Kusmi* (Ranchi) ♂ X Rangeeni (Jodhpur) ♀	34	200-250	225·6	All behaved as *kusmi* type

and scored for the resin dye-level and also for their rearing period, fecundity and resin secretion. The results are presented in Table 9c which show maternal effect for the resin dye-level.

The results of these crosses (Table 9b and 9c) provide clear evidence of considerable hybrid vigour in lac insects. However, the performance of F_1 hybrid females has differed with the direction of the cross and those with *kusmi* as the maternal parent have performed better than even the superior parent for fecundity and resin secretion.

TABLE 9b — REARING PERIOD AND RESIN SECRETION OF THE CROSSBRED FEMALES OF A CROSS OF *rangeeni* FEMALES AND *kusmi* MALES (AND THOSE OF THE MATERNAL PARENT STOCK)

	Rearing season	Rearing period (days)			Resin secretion (mg)		
		No. tested	Range	Mean	No. tested	Range	Mean
Maternal parent (*rangeeni*)	October-November to June-July	54	260-276	270·3	20	5·2-12·3	8·7
F_1	do	20	217-227	223·0	20	7·6-16·7	12·5
Maternal parent (*rangeeni*)	June-July to October-November	61	105-115	110·6	20	3·2-9·6	6·8
F_2	do	64	108-146	117·2	72	2·9-13·3	8·3

Utilization of hybrid vigour, thus appears to hold promise for improving lac productivity.

The lines derived from the strain crosses will now be evaluated under Project 1.5.8.

(N. S. Chauhan and J. Lal)

(b) RESEARCHES ON HAND

1.2 Physiological Studies on Lac Insects and Associated Insects

1.2.1 Nutritional requirement of predators, *Eublemma amabilis* and *Holcocera pulverea* and evolution of a suitable artificial diet

Lac insects (50 g) were dewaxed and freed of resin using appropriate solvents and then homogenized. A mixture of fats and steroids was extracted from the homogenate using chloroform: methanol (2:1 v/v). Proteins were extracted with dilute KOH and subsequently precipitated with TCA and the free amino acids by passing the aqueous filtrate of the homogenate through an ion exchange column and subsequent recovery using dilute ammonia solution.

Diets made up of 4 per cent agar-agar shreds, peptone, casein, glycogen, galactose, Wesson's salt mixture, fortified with fats, proteins and amino acids extracted from lac insects, were offered to newly hatched larvae of the lac predator, *Eublemma amabilis*. Rearing trials, however, could not be carried out as it was not possible to maintain constant temperature due to frequent load shedding. The work under this project has now been kept in abeyance.

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

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

Trials on improvement of artificial substrate made of agar agar were conducted with slight modifications in technique. A mixture of 4 g or 5 g agar agar in 100 ml water and 0·1 g to 0·5 g soft wax was boiled and solidified. Molten mixture was then allowed to cool to form the substrate for settlement of lac larvae. In another technique, agar agar slants of 4 and 5 percent concentrations were allowed

TABLE 9c — REARING PERIOD, FECUNDITY, RESIN SECRETION AND RESIN DYE-LEVEL OF THE *rangeeni* AND *kusmi* FEMALES AND THEIR F_1 HYBRID FEMALES REARED DURING THE RAINY SEASON

Mother	Father	Rearing period (days)			No. of larvae produced/female			Resin secretion/female			Optical density/mg resin		
		No. tested	Range	Mean	No. tested	Range	Mean	No. tested	Range	Mean	No. tested	Range	Mean
Rangeeni (Ranchi)	*Rangeeni* (Ranchi)	101	106-123	108·2	30	107-455	258·6	30	1·8-9·5	5·6	30	0·014-0·044	0·022
Kusmi (M.P.)	*Kusmi* (M.P.)	97	144-167	154·0	29	82-718	361·8	29	6·0-19·0	10·7	29	0·010-0·026	0·016
Rangeeni (Ranchi)	*Kusmi* (M.P.)	49	117-224	143·0	20	46-834	431·8	30	4·1-14·5	9·7	30	0·013-0·051	0·027
Kusmi (M.P.)	*Rangeeni* (Ranchi)	66	111-167	119·9	17	257-790	526·8	30	7·0-18·3	12·8	30	0·009-0·023	0·012

to soak 0·1, 0·2, 0·3, 0·4 and 0·5 percent soft wax in molten state to render hardness in the texture of the substrate. Results of inoculation of such substrates with lac larvae supplied with liquid diet through them (substrates) indicated that although addition of soft wax in the agar agar slant offered the hardness in texture of the substrate, it was unable to soak the diet in the first instance and later incapable of providing adequate softness for the lac larvae to penetrate their proboscis. As a result of such difficulties, the lac larvae were unable to feed and ultimately suffered mortality. Similarly, slants prepared by boiling gelatin in concentrations ranging from 0·1 and 0·2 percent with 4 and 5 percent agar agar did not hold good as the lac larvae suffered mortality due to same apparent difficulties, i.e., changes in the surface texture of substrates. As such, trials on improvement of the substrates did not yield promising results.

As a total substitute for agar agar slant 0·5, 1·0, 1·5 and 2 g of gelatin mixed in 100 ml water was boiled and then solidified for making slants. The lac larvae when released on such substrate did not even tend to settle probably due to non-spongy property of the gelatin.

Further efforts in the direction of fortification of the usual diet administered to the lac larvae in order to facilitate in their moulting could not be made due to non-availability of growth promoting substance. Under other different trials, however, made with the lac insects transferred from their natural hosts (*Moghania macrophylla*) to the artificial substrates after male energence, important observations revealed that the lac insects partly fed on their natural hosts up to a certain period (male emergence) and then transferred to the artificial substrates are capable of moulting (i.e., without administration of any growth promoting hormone). More systematic approach in this direction is likely to provide better results in terms of rate of growth and development as well as resin secretion in lac insect.

Efforts to obtain plant sap particularly from the phloem region where the lac insects are said to feed from, could not succeed as devices to obtain the same with the help of syringes and needles from deeper tissues (beyond cortical region) of succulent shoots of potted plants of *bhalia* failed to yield any substance. Thus, further study in this direction i.e., determination of certain specific requirement for analysis after study of the plant sap could not be taken up.

Rearing trials on usual pattern, however, with minor modifications such as changing the frequency of administration of diet, improving the consistency and texture of agar agar slants by cooling under referigerator were continued. Results did not indicate appreciable improvements in the early developmental stages of lac larvae. But during later stages the record of healthy growth, increase in the production of waxy filaments, honey dew as well as secretion of lac resin was very much distinct.

During *aghani* 1978-79 season, the larvae settled on agar slants soaked with the usual diet (D-1) survived for a maximum period of 125 days. During *katki* 1979, the maximum survival was for a period of 68 days and during *baisakhi* 1978-79 and *baisakhi* 1979-80, for 76 and 86 days respectively.

The desired extent of results could not be achieved during the year under report due to unavoidable difficulties in electricity and water supply throughout the year.

(A. H. Naqvi and R. Ramani)

1.2.3 Isolation and identification of micro-organisms present in the lac insect and determination of roles played by them in metabolism and resin secretion

Further attempts were made to evolve a suitable technique of destroying the symbiotic microflora in lac insect cultured on *bhalia* plants by way of foliar spray

of chloromycetin and terramycin (0·25%) on the plants. Microbiological tests showed all the four symbiotic micro-organisms remained unaffected with such applications. For want of any definite technique to destroy the internal micro-organisms (symbionts) harboured particularly by the lac insects characterized by their sedentary habits, further studies in this direction could not be pursued. Further efforts to develop alternate technique for the purpose could not be made due to certain unavoidable difficulties like electricity, gas and water facilities.

Other routine trials repeated during the year 1979 confirmed that the above mentioned antibiotics used in the synthetic diet administered to the lac larvae, reared on artificial substrates destroyed the microflora causing ultimately the total mortality of the lac larvae. This indicates that micro-organisms harboured by the lac insects have symbiotic role to play and that some kind of nutritional imbalances occur on account of destruction of these symbionts which ultimately affects the survival of lac larvae.

(A. H. Naqvi)

1.2.4 Studies on sex-attraction in major lepidopterous predators

Crude pheromone (0·05 mg) was extracted during the year 1979 from the abdominal tips of 2-day-old virgin females of *E. amabilis* and was stored at −10°C. It, however, deteriorated due to frequent load shedding and hence further studies could not be made.

Crude pheromone (0·02 mg) extracted, similarly, during 1980 was tested in an olfactometer with unmated males and was found effective. Further studies could not be carried out due to frequent load shedding.

(T. P. S. Teotia, A. K. Sen and K. M. Prasad)

1.3 Ecology of Lac Insect and Associated Insects

1.3.3 To study the bioecological aspects of *Pristomerus sulci*, endoparasite of *Holcocera pulverea*, one of the major predators of the lac insect

The adult parasites, in varying proportions of the two sexes were released in battery jars containing the first instar larvae of *Corcyra cephalonica*, tried as an alternate host. Mating was found to have been induced only when the parasites were released in the male: female ratio of 1:3, 2:1 and 3:1.

This work repeated in 1980 has confirmed the earlier observations.

(R. L. Tripathi and M. L. Bhagat)

1.3.5 Ecological studies taken up at Dharamjaigarh (M.P.)

The Regional Field Research Station at Dharamjaigarh (M.P.) continued to function during the period under report. The progress made under the various items of investigation is reported below:

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

The four cultivation practices tried earlier (A.R.: 1973) continued to remain under trial. The data collected are given in Table 10.

Jethwi-cum-aghani 1978-79

The crop performance was poor under all the treatments. The crop ratio for treatments A, B and C was 1:0·38, 1:0·30 and 1:0·24 respectively.

TABLE 10 — CROP PERFORMANCE UNDER THE DIFFERENT CULTIVATION PRACTICES TRIED FOR *kusum* AT DHARAMJAIGARH, M.P.

Crop	Treatment	Brood used (kg)		Yield (kg)		Crop ratio
		Lac stick	Sticklac	Lac stick	Sticklac	
JANUARY TO JANUARY CYCLE (1978-79)						
Jethwi 1978-*cum*-*Aghani* 1978-79	A	44·8	26·6	32·7	10·2	1 : 0·38
Jethwi 1978-*cum*-*Aghani* 1978-79	B	58·0	31·7	46·5	9·55	1 : 0·30
Jethwi 1978+ *Aghani* 1978-79	C	57·0	28·0	32·5	6·95	1 : 0·24
Jethwi 1978+ *Aghani* 1978-79	D	28·0	15·6	2·8	0·5	1 : 0·03
JULY TO JULY CYCLE (1978-79)						
Aghani 1978-79-*cum*-*Jethwi* 1979	A	Not inoculated in July 1978 due to non availability of brood lac				
Aghani 1978-79-*cum*-*Jethwi* 1979	B					
Aghani 1978-79+ *Jethwi* 1979	C	36·0	10·2	42·7	7·5	1 : 0·74
Aghani 1978-79+ *Jethwi* 1979	D	28·0	15·0	3·5	0·5	1 : ·03
JANUARY TO JANUARY CYCLE (1979-80)						
Jethwi 1979-*cum*-*Aghani* 1979-80	A	18·0	6·8	13·9	2·55	1 : 0·31
Jethwi 1979-*cum*-*Aghani* 1979-80	B	18·90	5·7	19·0	3·4	1 : 0·59
Jethwi 1979+ *Aghani* 1979-80	C	43·2	7·2	21·8	4·21	1 : 0·58
		36·0	10·2	42·7	7·5	1 : 0·69
	Av.	39·6	8·7	32·25	5·6	1 : 0·64
Jethwi 1979+ *Aghani* 1979-80	D	16·2	4·0	Not harvested		
JULY TO JULY CYCLE (1979-80)						
Aghani 1979-80-*cum*-*Jethwi* 1980	A	21·8	4·2	43·9	10·31	1 : 2·45
Aghani 1979-80-*cum*-*Jethwi* 1980	B	21·8	4·1	12·2	1·21	1 : 0·30
Aghani 1979-80+ *Jethwi* 1980	C	43·2	7·2	21·8	4·21	1 : 0·58
		66·9	25·0	61·3	93·25	1 : 0·37
	Av.	55·05	16·1	41·55	6·767	1 : 0·48
Aghani 1979-80+ *Jethwi* 1980	D	52·0		Not harvested		

Jethwi-cum-aghani 1979-80

The crop was rather poor under all the treatments. The crops ratio for treatments A, B and C were 1:0·31, 1:0·59 and 1:0·64 respectively.

Aghani-cum-jethwi 1978-79

The initial *aghani* 1978-79 crop could not be raised due to non-availability of brood lac. The *jethwi* 1979 raised was best under treatment C with a crop ratio of 1:0·74.

Aghani-cum-jethwi 1979-80

The *aghani* 1979-80 crop was satisfactory under treatments A, B and C. The subsequent *Jethwi* crop progressed satisfactorily till May but it was severely affected due to heat thereafter and no brood lac was produced. The crop ratio under treatments A, B and C were 1:2·45, 1:0·30 and 1:0·48 respectively.

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

One tree each of *dumar* (*Ficus racemosa*) and *jhera* (*Ficus* sp.) were inoculated to raise the *jethwi* 1979 crop but none produced a crop.

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

One kg samples of unselected brood lac were caged in each crop to note emergence of insects therefrom. No new insect species was recorded.

One kg samples of unselected brood lac were collected from two places viz. Chonehal (M.P.) on 1 January 1980 and Bharno (Bihar) on 24 January 1980 and caged for noting the emergence of insects therefrom. The total number of insects recorded are given below:

	Chonehal (M.P.)	Bharno (Bihar)
Eublemma amabilis	25	18
Holcocera pulverea	6	16
Pristomerus sulci	6	—
Erencyrtus dewitzi	—	2
Tachardiaephagus tachardiae tachardiae	6	9
Apanteles tachardiae	—	2

(R. L. Tripathi, B. N. Sah and J. M. Das Gupta)

1.3.6 To study the population dynamics of *kusmi* strain of lac insect to ascertain the causes of *kusmi* crop failures

The experiment was carried out on 24 *kusum* trees. In the *jethwi* 1980 and *aghani* 1980-81 crops, samples were drawn from three canopies, namely, lower, middle and upper from each of the four quadrants, namely, north, east, south and west of the lac-bearing trees and examined for total number of (i) lac insects (live and dead), (ii) predators and (iii) parasites. In all, 36 samples were collected per tree at fortnightly interval.

It has been found that the lac larval density differed significantly between the canopies. The lac insect survival was found to be better in upper canopy than in the lower but this difference was not so marked with the progress of the crop. The lac larval density was also found to differ between quadrants within the tree.

Among the lac predators, *E. amabilis* was more prevalent than *Holcocera pulverea* and the incidence of predators was higher in the lower canopy than in the upper.

(B. N. Sah and M. L. Bhagat)

1.3.8 Studies on the factors affecting *rangeeni* lac insects

This is a new item of investigation taken up in 1980 to develop a sampling plan for the study of *rangeeni* lac insect populations for numerical changes and the factors responsible thereof.

The *katki* 1980 crop was raised on fifteen *palas* (*Butea monosperma*) trees using normal brood rate. Samples were drawn 21 days after larval settlement at ten day interval from five trees at two canopy levels i.e., lower and upper. For this purpose, one lac-bearing shoot was drawn at random from each canopy and divided into three sectors, namely, the basal, middle and apical. One inch length was examined from each sector. The samples collected up to the time of sexual maturity could not be examined in time and were lost. Those examined during the post-metamorphic period showed that, on an average, 73 percent insects were damaged due to parasitisation and predation. Surprisingly, parasitic losses were not found lesser than those due to the predators.

The study made during the *baisakhi* 1980-81 crop has shown that about 6·5 percent lac larvae failed to emerge from the mother cells, 25 percent were dislodged during the first three weeks due to weather and the remaining population was further reduced to about half due to starvation before settlement. This mortality was restricted to hairy and such portions of the shoot where the outermost layer was fully dead and cast off. The parasites did not appear till the end of the period under report but the eggs of predators were observed.

No difference was found in the population of lac insects between the two canopies. The data for the three sectors of the shoot were not consistent.

(D. C. Srivastava)

1.3.9 Studies on lac larval settlement and factors affecting

This project has been taken up in 1980 to study the factors affecting lac larval settlement with a view to increasing the coverage of host plants by lac insects for increased lac production.

The experiments were carried out on potted plants of *bhalia* inclined at varying angles (0°, 45°, 60°, 75°, 90°, 105° and 120°) from the ground level from east to west. Three plants were taken for each inclination. Inoculation of the plants with lac insect showed that the coverage was all around the plant at inclinations of 75°, 90° and 105°. Plants inclined at 60° and less were found to be covered only on the lower surface. These observations suggest that the lac larvae prefer shade for their settlement.

Based on the above observations, an experiment was laid out on *palas* trees at Kundri lac orchard. Thirty trees were selected and divided into three groups with equal number of trees. The shoots of the trees of one group were tied with their apex pointing upwards, those of the second group pointing downwards and those of the third group were left undisturbed. These trees were then inoculated with lac insects. The shoots were untied after larval settlement had taken place. Yield data are expected in June-July next year.

(Y. D. Mishra)

1.4 Control of Enemies of Lac Insects

1.4.3 Relative toxicity of newer synthetic insecticides and plant poisons to predators and parasites vis-a-vis lac insect

The project which remained suspended earlier was again taken up for studies in 1979, with the object of exploring the possibilities of controlling the lac predators by the use of newer synthetic insecticides and plant poisons safer to the lac insects and its beneficial biota and toxic to enemy insects of lac, comprising both the parasitic and predaceous fauna.

1.4.3.1 Screening of newer synthetic insecticides for their safety to the lac insect and toxicity to the lac predators

(i) *Baisakhi* 1978-79 crop on *bhalia* (*Moghania macrophylla*) at Amjharia

In the above crop, 8 insecticides, namely, Ekamet, phosphamidon, quinalphos, phosalone, nuvacron, anthio, cythion, methoxychlor and a water control were sprayed at about 3 1/2-4 1/2 months old lac crop. A concentration of 0·1 percent i.e., highest tried of Ekamet, quinalphos, phosalone and cythion proved toxic to lac nymphs, methoxychlor even @ 0·2 percent proved safer, whereas lower concentrations i.e., those ranging from 0·025 to 0·05 percent of the rest proved safer (Table 11a).

(ii) *Jethwi* 1979 crop on *bhalia* at Amjharia

About two months old lac crop was sprayed with the insecticides, namely, cythion, phosphamidon, quinalphos and phosalone along with a water control with three concentrations ranging from 0·00625 to 0·025 percent. Again there are indications that higher concentrations are toxic whereas lower ones are safer (Table 11b).

(iii) *Katki* 1979 crop on *bhalia* at Amjharia

Expt. I — About 3-23 days old lac crop was sprayed with the insecticides, namely, Ekamet, Cythion, methoxychlor, phosphamidon sevin, quinalphos at three concentrations ranging from 0·025 to 0·1 percent. High mortality was recorded in Ekamet, methoxychlor, sevin and quinalphos. Only lowest concentration of phosphamidon proved safer. Since the control also gave higher than normal mortality, the trials need repetition (Table 11c)

Expt. II — Another trial was made with three concentrations of Padan, sumithion, sumicidine and dimethoate, ranging from 0·00625 to 0·025 and water control, on 30-50 days old crop. Two lower concentration of sumithion and sumicidine and highest of dimethoate proved toxic (Table 11d).

(iv) *Baisakhi* 1979-80 crop on *bhalia* at Amjharia

Ten insecticides, namely, Ekamet, Cythion, methoxychlor, Dimecron, padan, sevin, dimethoate, sumithion, sumicidin and quinalphos, were sprayed in three concentrations, along with a water spray control, on about 70-80 days old lac crop and observations on mortality taken after a fortnight. 0·0125 and 0·025 of sumithion, 0·025 of sumicidin and 0·1 per cent of quinalphos, all proved safer (Table 11e).

In another experiment the above mentioned insecticides were sprayed on 6-16 day old lac nymphs. Observations revealed heavy mortality of lac nymphs with almost all the insecticides except Padan (Table 11f).

This needs repetition.

TABLE 11a — SCREENING OF INSECTICIDES

Crop: *Baisakhi* 1978-79
Date of inoculation: 21 October 1978
Date of *phunki* removal: 21 November 1978
Date of spraying: 23 February 1979 (on 104-134-day-old lac nymph)

Insecticides and their concentrations		No. of lac nymphs under observation	Percentage of mortality	Corrected percent mortality
Ekamet	0·1	73	89·6	67·29
	0·05	80	43·9	Nil
	0·025	69	32·2	Nil
Phosphamidon	0·1	92	66·3	Nil
	0·05	102	59·5	Nil
	0·025	94	52·8	Nil
Quinalphos	0·1	86	84·8	52·20
	0·05	78	53·9	Nil
	0·025	84	42·5	Nil
Phosalone	0·1	109	84·6	51·57
	0·05	95	72·3	12·89
	0·025	82	43·9	Nil
Nuvacron	0·1	69	68·2	Nil
	0·05	79	72·7	14·15
	0·025	83	61·7	Nil
Anthio	0·05	76	64·9	Nil
	0·025	99	54·8	Nil
	0·0125	110	47·8	Nil
Cythion	0·05	151	79·0	93·96
	0·025	91	54·2	Nil
	0·0125	98	42·1	Nil
Methoxychlor	0·2	67	43·4	Nil
	0·1	94	42·9	Nil
	0·05	41	63·5	Nil
Water spray control		107	68·2	

TABLE 11(b)

Crop: *Jethwi* 1979
Date of inoculation: 22 February 1979
Date of *phunki* removal: 22 March 1979
Date of spraying: 22 April 1979 (on 30-58-day-old lac nymphs)

Insecticides and their concentrations		No. of lac nymphs under observation	Percentage of mortality	Corrected percent mortality
Cythion	0·025	102	87·9	49·79
	0·0125	124	62·3	Nil
	0·00625	139	60·4	Nil
Phosphamidon	0·025	160	79·0	12·86
	0·0125	169	68·7	Nil
	0·00625	209	58·2	Nil
Quinalphos	0·025	115	72·2	Nil
	0·0125	153	82·6	27·80
	0·00625	141	66·5	Nil
Phosalene	0·025	206	78·4	10·37
	0·0125	182	78·8	12·03
	0·00625	69	71·1	Nil
Water spray control		124	75·9	—

TABLE 11(c)

Crop: *Katki* 1979
Date of inoculation: 6 July 1979
Date of *phunki* removal: 26 July 1979
Date of spraying: 29 July 1979 (on 3-23-day-old lac nymphs)

Insecticides and their concentrations		No. of lac nymphs under observation	Percentage of mortality	Corrected percent mortality
Ekamet	0·1	198	96·6	88·22
	0·05	338	95·4	84·06
	0·025	305	88·96	61·75
Cythion	0·05	416	78·46	25·38
	0·025	356	84·36	45·82
	0·0125	295	56·33	Nil
Methoxychlor	0·1	257	85·6	50·12
	0·05	319	100·00	100·00
	0·025	343	78·93	27·01
Phosphamidon	0·1	362	76·03	16·97
	0·05	77	85·8	50·81
	0·025	249	57·46	Nil
Sevin	0·2	276	82·75	40·24
	0·1	306	78·06	24·00
	0·05	78	82·1	37·99
Quinalphos	0·1	184	90·35	66·57
	0·05	259	93·83	78·62
	0·025	295	84·16	45·13
Control (No treatment)		306	71·13	

TABLE 11(d)

Crop: *Katki* 1979
Date of inoculation: 6 July 1979
Date of *phunki* removal: 26 July 1979
Date of spraying: 26 August 1979 (on 30-50-day-old lac nymphs)

Insecticides and their concentrations		No. of lac nymphs under observation	Percentage of mortality	Corrected percent mortality
Padan (thiocyclam)	0·00625	142	56·33	45·75
	0·0125	71	21·76	2·80
	0·025	105	11·93	Nil
Sumicidine	0·00625	102	25·53	7·49
	0·0125	98	20·43	1·15
	0·025	124	70·00	62·73
Sumithion	0·00625	127	20·43	1·15
	0·0125	116	19·06	Nil
	0·025	130	52·43	40·90
Dimethoate	0·00625	132	88·10	85·21
	0·0125	88	71·13	64·13
	0·025	108	54·40	43·47
Control (No treatment)		105	19·50	

TABLE 11(e)

Crop: *Baisakhi* 1979-80
Date of inoculation: 30 October 1979
Date of spraying: 18 January 1980 (on 70-80-days-old lac crop)
Date of *phunki* removal: 8 November 1979

Insecticides and their concentrations (%)		No. of lac nymphs under observation	Av. percent mortality after 15 days	Correted percent mortality
Ekamet	0·1	143	30·40	2·57
	0·05	182	20·90	Nil
	0·025	177	9·00	Nil
Cythion	0·05	163	24·50	Nil
	0·025	153	28·20	Nil
	0·0125	205	20·25	Nil
Methoxychlor	0·1	128	15·05	Nil
	0·05	166	18·10	Nil
	0·025	130	8·85	Nil
Dimecron	0·1	139	26·95	Nil
	0·05	156	15·70	Nil
	0·025	154	18·90	Nil
Padan	0·025	117	33·30	6·63
	0·0125	124	5·65	Nil
	0·00625	134	29·65	1·52
Sevin	0·2	146	17·55	Nil
	0·1	156	29·95	1·94
	0·05	104	13·60	Nil
Dimethoate	0·025	154	36·15	10·62
	0·0125	147	34·85	8·80
	0·00625	134	27·10	Nil
Sumithion	0·025	101	39·25	14·96
	0·0125	122	36·30	10·83
	0·00625	117	22·50	Nil
Sumicidine	0·025	124	38·10	13·35
	0·0125	106	30·60	2·85
	0·00625	115	8·20	Nil
Quinalphos	0·1	134	53·40	34·77
	0·05	113	29·00	6·15
	0·025	187	25·20	Nil
Water spray		186	22·13	Nil
Control ((No treatment		197	28·56	Nil

(v) *Jethwi* 1980 crop on *bhalia*

(I) Ten insecticides, namely, padan, sevin, methoxychlor, phosphamidon, dimethoate, quinalphos, evisect, phosalone, sumithion and sumicidine at three concentrations were sprayed about 2-28 day-old lac nymphs. Except, sevin (0·1

TABLE 11(f)

Crop: *Baisakhi* 1979-80
Date of inoculation: 30 October 1979
Date of *phunki* removal: 8 November 1979
Date of spraying: 14 November 1979 (on 6-16 days-old lac crop)

Insecticides and their concentrations (%)		No. of lac nymphs under observation	Percentage of mortality	Corrected percent mortality
Ekamet	0·1	86	100	100·00
	0·05	157	100	100·00
	0·025	80	97·5	92·36
Cythion	0·05	72	94·5	83·20
	0·025	96	46·9	Nil
	0·0125	76	55·3	Nil
Methoxychlor	0·1	96	62·5	Nil
	0·05	107	55·2	Nil
	0·025	77	94·9	84·42
Padan	0·025	84	42·9	Nil
	0·0125	65	44·7	Nil
	0·00625	50	56·0	Nil
Sevin	0·2	64	31·3	Nil
	0·1	104	70·2	8·97
	0·05	66	81·9	44·71
Dimethoate	0·025	107	96·3	88·69
	0·0125	79	72·2	15·08
	0·00625	85	94·2	82·28
Sumithion	0·025	74	82·5	46·54
	0·0125	61	91·9	75·25
	0·00625	64	86·0	57·23
Quinalphos	0·1	69	100	100·00
	0·05	78	98·8	96·33
	0·025	76	100	100·00
Dimecron	0·1	67	100	100·00
	0·05	81	93·9	81·36
	0·025	79	63·4	Nil
Water spray		293	36·86	Nil
Control (No treatment)		257	67·26	

and 0·2%), phosphamidon (0·025%), sumithion (0·00625%) and evisect (0·025% conc.), all proved toxic, at this stage of the lac nymphs (Table 11g).

(II) In another experiment 50-77 day-old lac nymphs were sprayed with the above ten insecticides at three concentrations. Almost all the insecticides proved safer at this stage (Table 11h).

TABLE 11(g)

Crop: *Jethwi* 1980
Date of inoculation: 30 January 1980
Date of *phunki* removal: 26 February 1980
Date of spraying: 28 February 1980 (on 2-28 days-old lac nymphs)

Insecticides and their concentrations (%)		No. of lac nymphs under observation	Av. percent mortality	Corrected percent mortality
Padan	0·025	72	100·00	100·00
	0·0125	72	100·00	100·00
	0·00625	126	87·31	50·54
Sevin	0·2	88	77·28	11·45
	0·1	59	78·00	14·26
	0·05	69	97·11	88·73
Methoxychlor	0·1	67	85·08	41·85
	0·05	120	90·84	64·30
	0·025	75	86·67	48·05
Phosphamidon	0·1	111	95·50	82·46
	0·05	59	92·23	73·61
	0·025	97	79·39	19·68
Dimethoate	0·025	81	76·55	8·61
	0·0125	119	89·92	60·71
	0·00625	98	96·94	88·07
Sumithion	0·025	49	100·00	100·00
	0·0125	68	98·53	94·27
	0·00625	97	75·26	3·58
Sumicidin	0·025	87	100·00	100·00
	0·0125	92	83·70	36·47
	0·00625	77	98·71	94·97
Quinalphos	0·1	61	100·00	100·00
	0·05	102	100·00	100·00
	0·025	52	100·00	100·00
Evisect	0·05	66	86·37	46·88
	0·025	96	58·34	Nil
	0·0125	81	88·89	56·70
Phosalone	0·05	83	87·96	53·07
	0·025	86	97·68	90·95
	0·0125	90	92·23	69·71
Control water spray		187	74·34	—

(vi) *Aghani* 1980-81 crop on *bhalia*

Since Ekalux and Dimecron had proved safer to two month old lac nymphs in previous studies, a microplot field trial was laid out under a randomized block design with the above insecticides along with Thiodan® as the standard for com-

TABLE 11(h)

Crop: *Jethwi* 1980
Date of inoculation: 30 January 1980
Date of *phunki* removal: 26 February 1980
Date of spraying: 17 April 1980 (on 50-77-days-old lac nymphs)

Insecticides and their concentrations		No. of lac nymphs under observation	Av. percent mortality	Corrected percent mortality
Sevin	0·2	64	37·23	Nil
	0·1	71	45·20	Nil
	0·05	36	80·56	34·2
Padan	0·025	70	50·89	Nil
	0·0125	66	74·24	24·7
	0·00625	67	84·26	54·00
Phosphamidon	0·1	28	42·96	Nil
	0·05	64	31·00	Nil
	0·025	68	32·64	Nil
Dimethoate	0·025	79	67·68	5·5
	0·0125	95	40·44	Nil
	0·00625	33	6·07	Nil
Sumithion	0·025	41	63·42	Nil
	0·0125	41	63·42	Nil
	0·00625	77	53·44	Nil
Sumicidin	0·025	37	54·06	Nil
	0·0125	78	44·67	Nil
	0·00625	91	59·78	Nil
Quinalphos	0·1	70	62·00	Nil
	0·05	36	58·34	Nil
	0·025	31	35·49	Nil
Evisect	0·05	76	50·57	Nil
	0·025	67	50·45	Nil
	0·0125	79	70·06	12·5
Phosalone	0·05	34	64·71	Nil
	0·025	35	42·86	Nil
	0·0125	31	54·84	Nil
Water spray		35	82·86	49·6
Control (No treatment)		70	65·77	

parison at 0·05 percent concentration on 15 bushes each (three replications, with 5 bushes per replication), along with a control i.e., all told 60 bushes. Crop was inoculated on 6th of July, 1980 and two sprayings were given on 25 September 1980 and 4 December 1980 (Table 11i)

Post-treatment observations taken after 15 days of each spraying revealed that as a result of first spraying, the insecticide Ekalux proved superior in which 87·49

percent corrected mortality of the lac predator, *Holcocera pulverea* was recorded, whereas as a result of second spraying the insecticide Thiodan® proved superior affording 88·2 percent mortality of *H. pulverea* and 62·5 percent that of *Eublemma amabilis* (Table 11j).

The treatments, namely, 0·05 percent Thiodan® and Dimecron, gave about double the yield of scraped lac whereas Ekalux about one and half times than the control.

Trials need repetition.

(C. P. Malhotra, Y. D. Misra and S. G. Choudhary)

TABLE 11(i)

Crop: *Aghani* 1980-81
Date of inoculation: 6 July 1980
Date of *phunki* removal: 19 July 1980
Date of observations: 7/8 October 1980
Date of spraying: 25 September 1980

Treatment	Concentration (%)	Living		Dead		Mortality (%)		Corrected percent mortality
		E.a.	*H.p.*	*E.a.*	*H.p.*	*E.a.*	*H.p.*	
Thiodan	0·05	1 larva 1 pupa	23	—	67	—	74·5	71·27
Ekalux	0·05	—	6	—	55	—	88·9	87·49
Dimecron	0·05	2	31	—	58	—	65·1	60·68
Control	—	4	32	—	4	—	11·22	—

TABLE 11(j)

Crop: *Aghani* 1980-81
Date of inoculation: 6 July 1980
Date of *phunki* removal: 19 July 1980
Date of observation: 11 December 1980
Date of spraying: 4 December 1980

Treatment	Concentration (%)	Living		Dead		Mortality (%)	
		E.a.	*H.p.*	*E.a.*	*H.p.*	*E.a.*	*H.p.*
Thiodan	0·05	6	2	10	15	62·5	88·23
Ekalux	0·05	14	3	11	7	44·0	70·0
Dimecron	0·05	12	13	5	11	29·42	45·83
Water spray control	—	13	22	—	—	—	—
Control	—	7	14	—	—	—	—

1.4.4 Laboratory evaluation of the efficacy of microbial agents for the control of lepidopterous predators

The project aims at survey and evaluation of various microbial agents isolated from diseased lepidopterous pests for their pathogenicity and selective toxicity to the lac predators and harmlessness to the lac insect.

Lac predators were collected from brood lac and *phunki* lac of different areas. Attempts were made to sort out the diseased population of predators on the basis of preliminary symptons. Pure as well as mixed isolates were tested for their pathogenicity, but these were not found highly virulent to cause disease in the healthy population of lac predator.

(S. C. Choudhary and A. H. Naqvi)

1.4.8 Studies on the sterilization of lepidopterous predators by irradiation

Efforts to maintain field collected larvae of the lac predator, *E. amabilis*, on scraped lac were not successful as most of them died before pupation and hence the study could not be taken up.

This study has now been kept in abeyance till a satisfactory rearing technique is developed for the lac predators.

(Y. D. Mishra and C. P. Malhotra)

1.4.12 Studies on biological control of lac insect predators — *Holcocera pulverea* and *Eublemma amabilis* by parasites *Bracon greeni* and *Apanteles tachardiae*

The project was taken up in 1980. Necessary exploratory and planning work was done to initiate the study.

(C. P. Malhotra, D. C. Srivastava, A. Bhattacharya and P. Sen)

1.5 Genetics and Breeding of Lac Insects

1.5.5 Cytological studies in lac insects

Cytological studies on *Kerria lacca* (Kerr) have confirmed a 'Lecanoid' system of chromosome behaviour as has been unravelled in the mealy bug *Planococcus citri* (Risso). It has been observed that one haploid set of chromosomes becomes heterochromatized during the early embryogeny of the male whereas the other set remains euchromatic.

Studies on spermatogenesis have shown that during the first division, the euchromatic and heterochromatic nuclei divide equationally to form the quadrinucleate spermatids. The two types thereafter separate to form two heterochromatic and two euchromatic nuclei. Only the euchromatic sets form the sperms.

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

1.5.7 Protein polymorphism and genetic hetrozygosity in lac insect population

Tetrazolium oxidase

The presence of tetrazolium oxidase as a polymorphic protein was reported last year in the body extract of the female *kusmi* lac insect. During the year under report, the *rangeeni* lac insect was also studied for the presence of this enzyme and

its isozymes. For this purpose, the fully mature females were crushed in phosphate buffer *p*H 7, homogenized and centrifuged at 10,000 rpm for 15 min. The supernatant was subjected to acrylamide disc-gel electrophoresis. The electrophoresis was conducted for 90 minutes at 300 volts. The gels were rimmed out and kept in a staining mixture of 0·005 m $MgCl_2$, 0·001 M D.P.N., 0·0043 M NB tetrazolium and 0·000163 M phenazine methosulphate prepared shortly before use in 100 ml of phosphate buffer *p*H 9 under light. The gels were washed in acetic acid (1 percent) and studied for the presence of the enzyme.

Three achromatic bands appeared on the gel providing a situation as was reported for the female *kusmi* lac insect last year. The presence of tetrazolium oxidase has thus been confirmed in both the strains of lac insect as a polymorphic protein in three molecular forms.

Glucose-6-phosphate dehydrogenase

The two strains were also studied for the presence of glucose-6-phosphate dehydrogenase. For this purpose, fully mature females of both strains were homogenized in tris buffer *p*H 7 and centrifuged at 10,000 rpm for 10 min.

The gels were prepared in the usual way except for the addition of 4 mg of T.P.N. per 100 ml of gel solution before polymerization. Electrophoresis was carried out for three hr at 300 volts. The gels were then rimmed out and stained in a staining mixture containing 0·00056 m glucose-6-phosphate, 0·005 M $MgCl_2$, 0·00013 M T.P.N., 0·00012 M NB tetrazolium, 0·00013 M phenazine methosulphate and 0·05 M tris *p*H 8·0 prepared shortly before use. The gels were stained for 3 hr at room temperature.

One band appeared on the gel confirming the presence of Glucose-6-phosphate dehydrogenase as a monomorphic protein in these strains.

Proteins

With a view to study protein differences in lac insects, the adult females of two wild stocks of the *rangeeni* strain of lac insect, namely, local crimson and Delhi yellow were compared for their proteins. The females were homogenized in distilled water containing 0·002 M $MgCl_2$ and centrifuged at 14000 rpm for 10 min. The supernatant was subjected to disc-gel electrophoresis at 300 V for 90 minutes. The gels were then rimmed out and stained with amido black staining solution (1%) for one hour and destained by acetic acid (1%) for 3 days.

Five bands appeared on the gel in the case of local crimson stock and six in the case of Delhi yellow, showing clearly that the two stocks of the same *rangeeni* strain differed in their proteins. It was of interest to observe here that before staining two red bands appeared on the gel in the case of local crimson stock and three yellow bands for Delhi stock. On staining with amido black these coloured bands were also stained for the proteins and corresponded with the fast moving protein bands. These observations suggest that the lac insect pigments do not occur in a free state but are linked with certain proteins.

Attempts were made to isolate and identify the isozymes of alkaline phosphatase through disc-gel electrophoresis and histochemical staining procedures involving cobalt nitrate, sodium bisulphite etc. but the system could not work and the whole gel turned black. The experiment could not be conducted further due to frequent load shedding.

(Y. D. Mishra, T. P. S. Teotia and N. S. Chauhan)

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

Seven *rangeeni* and six *kusmi* stocks were maintained and evaluated for their economic qualities. The data set out in Table 12 provide evidence of genetic variation in all the qualities scored. It may be seen from these results that the stocks originating from the north-eastern region (Assam and Meghalaya) have behaved differently from the other *rangeeni* and *kusmi* strains in their rearing periods. These stocks also produced a very dark coloured resin. The resin secretion has been maximum in the *kusmi* (yellow) stock originating from Orissa which also produced the much desired lighter coloured resin. The data for resin dye-level for certain *kusmi* stocks being rather unusual, the resin dye-level of such stocks needs further evaluation.

(J. Lal)

1.5.10 Studies on sex-determination in lac insects

Sex ratio was studied in individual progenies of a *rangeeni* and a *kusmi* stock of the Indian lac insect and a F_3 of a cross of *rangeeni* females and *kusmi* males. Fifty or more progenies were reared of each stock during the dry season, each maintained on a potted plant of *bhalia* (*Moghania macrophylla*) under cover of a 80-mesh synthetic netting sleeve cage to check the ingress of insects from outside and to prevent losses due to parasitic and predatory activity. All experiments were carried out in the Institute plantation at Namkum. The results are set out in Table 13a.

It will be seen from Table 13a that the progeny size and sex ratio varied within wide limits in all the stocks studied. Comparison of the *rangeeni* and *kusmi* strains showed that they differed distinctly both for progeny size and sex ratio and the F_3 behaved as an intergrade, suggesting that these strain differences are genetic. The *rangeeni* strain produces a large progeny with a higher proportion of males compared to the *kusmi*. The significant deviation of the sex ratio of F_3 in the direction of the *rangeeni* parent is expected since in *K. lacca*, the F_2 in fact represents a backcross to the maternal parent due to non-transmission of paternal chromosomes by the male.

Since the progeny size also varied widely, sex ratio was also studied in relation to the progeny size. For this purpose, the progenies were classified into three groups according to their size. Those including up to 50 insects were considered as small, between 51 and 150 as medium and over 150 as large. It will be seen from Table 13b that the sex ratio varied widely within each size group. The average proportion of males, however, was lowest in the small progenies and highest in the large in all the three stocks, suggesting that the male proportion tends to increase with the increase in the size of the progeny which is also consistent with the differences recorded for the two strains. This trend has been most marked in the stock (*rangeeni*) with the largest progeny size.

An interesting feature of the results, however, has been the record of the occasional occurrence of a unisexual progeny of either sex. It will be seen from Table 13c that while the all-female progenies were all small in size, the all-male progenies were recorded in all the size groups which can not be explained by chance or differential sexual mortality.

(N. S. Chauhan)

TABLE 12 — AVERAGE REARING PERIOD, NUMBER OF LARVAE PRODUCED PER FEMALE, RESIN SECRETION AND RESIN DYE-LEVEL OF THE DIFFERENT STOCKS OF LAC INSECTS

Stock	Rearing season	Rearing period (days)		No. of larvae produced/female		Resin secreted/female (mg)		Resin dye-content (Optical density)	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
Rangeeni									
Ranchi (Yellow)	Summer	240-266	257·39	92-1322	612·7	4·0-15·3	9·54	0·008-0·024	0·016
	Rainy	106-126	108·17	107-455	258·57	1·6-7·8	4·27	0·014-0·044	0·022
Kundri (Bihar)	Summer	254-276	265·16	104-1040	519·33	3·6-10·2	6·95	0·017-0·042	0·026
	Rainy	105-125	120·80	166-521	331·41	3·0-7·8	5·39	0·016-0·068	0·028
Umaria (M.P.)	Summer	251-276	262·39	197-728	490·66	9·5-18·8	13·94	0·015-0·030	0·015
	Rainy	106-122	114·77	92-605	406·27-	1·9-9·4	6·66	0·015-0·046	0·021
Delhi	Summer	243-272	257·77	157-766	517·95	3·2-14·2	9·15	0·013-0·034	0·023
	Rainy	105-126	115·43	198-512	330·54	5·1-11·9	7·64	0·016-0·029	0·021
Ludhiana (Punjab)	Summer	239-269	254·54	148-739	444·27	3·9-13·5	10·07	0·011-0·038	0·023
	Rainy	80-111	97·99	41-352	203·20	2·3-8·4	5·10	0·017-0·038	0·025
Assam (Mikir hill)	Summer	190-204	195·2	20-480	222·4	2·6-9·3	5·70	0·031-0·110	0·057
	Rainy	145-161	153·70	105·590	330·00	3·5-16·6	10·33	0·035-0·108	0·061
Meghalaya (Nongpoh)	Summer	194-236	215·25	21-485	225·27	2·3-12·6	6·43	0·029-0·109	0·052
	Rainy	113-163	147·75	45-612	370·70	3·8-18·2	11·86	0·035-0·124	0·056
Kusmi									
Ranchi	Summer	153-175	159·92	110-663	385·33	2·9-7·0	5·09	0·020-0·050	0·034
	Rainy	222-236	228·00	42-358	188·87	3·2-23·1	14·31	0·013-0·058	0·024
Dharamjaigarh, M.P. (Early maturing)	Summer	150-175	161·2	78-730	274·00	1·3-14·6	5·35	0·010-0·076	0·033
	Rainy	204-225	216·72	88-620	350·50	4·7-19·0	9·75	0·012-0·046	0·028
Dharamjaigarh, M.P. (Late maturing)	Summer	202-238	221·25	32-737	283·5	1·6-10·4	4·6	0·013-0·050	0·029
	Rainy	144-167	153·95	82-718	361·80	5·2-17·3	9·53	0·010-0·026	0·016
Orissa (Crimson)	Summer	168-195	178·08	64-626	263·27	1·5-9·8	4·45	0·017-0·053	0·027
	Rainy	189-219	203·32	—	—	8·6-26·6	17·53	0·011-0·025	0·016
Orissa (Yellow)	Summer	170-204	183·73	139-750	329·71	1·9-13·4	8·19	0·011-0·042	0·020
	Rainy	198-214	203·00	—	—	16·0-22·7	19·14	0·010-0·014	0·012
Madurai (Tamil Nadu)	Summer	123-154	137·7	35-600	262·00	1·8-16·6	7·1	0·010-0·050	0·016
	Rainy	207-226	251·82	120-660	314·00	4·2-16·6	10·42	0·012-0·045	0·026

TABLE 13(a) — PROGENY SIZE AND SEX RATIO IN A *rangeeni* AND A *kusmi* STICKS OF *K. lacca* AND IN A F_3 OF A CROSS OF *rangeeni* FEMALE AND *kusmi* MALE

	Rangeeni	*Kusmi*	F_3
No of progenies	43	82	63
No. of insects/progeny			
(i) Range	7-258	3-315	12-417
(ii) Mean	117-3	90·6	104·2
Sex ratio (% male)			
(i) Range	9·9-84·0	0·0-100·0	0·0-79·7
(ii) Mean	57·5	34·2	50·7

TABLE 13(b) — SEX RATIO IN RELATION TO PROGENY SIZE

Stock	Progeny size	No. of progenies	No. of insects/progeny		Sex ratio (% male)	
			Range	Mean	Range	Mean
Rangeeni	Small	6	7-45	22·3	14·4-53·8	29·1
	Medium	23	53-142	92·8	9·9-77·2	53·2
	Large	14	152-258	198·4	48·1-84·0	62·3
Kusmi	Small	39	3-50	25·9	0·0-100·0	27·9
	Medium	25	61-148	106·6	5·2-100·0	29·6
	Large	19	157-315	197·6	18·5-100·0	39·1
F_3	Small	12	12-50	30·5	0·0-75·0	43·2
	Medium	40	51-142	95·6	26·7-68·5	49·5
	Large	11	153-417	217·4	28·7-97·7	53·7

(c) RESEARCHES CONTEMPLATED

(1) Studies on the possibility of lac cultivation on *palas* and *khair* in alternation.

(2) Studies on some physiological aspects of lac insect in relation to host plants.

(3) Biochemical studies on the lac insect to ascertain strain differences.

(4) Histo-physiology of lac glands.

(5) Studies on the economic threshold of *Eublemma amabilis* and *Holcocera pulverea* infesting lac crop.

(6) Cytotaxonomy of lac insects.

(7) Laccaic acid as a biological stain

(8) Abundance of lac pests in relation to different agro-climatic situations and lac insects of different places.

(d) OPERATIONAL RESEARCH PROJECT

In the project area, comprising of four villages namely, Hardag, Barguttoo, Saheda and Koenjari in Ranchi district, operational researches for all round

TABLE 13(c) — DISTRIBUTION OF BISEXUAL AND UNISEXUAL PROGENIES

Stock	Progeny size	No. of progenies			Total
		Bisexual	Unisexual		
			All-male	All-female	
Rangeeni	Small	6 (7-45)	0	0	6
	Medium	23 (53-142)	0	0	23
	Large	14 (152-258)	0	0	14
Kusmi	Small	34 (3-50)	1 (14)	4 (4-24)	39
	Medium	24 (61-148)	1 (83)	0	25
	Large	18 (157-315)	1 (307)	0	19
F_3	Small	10 (12-50)	0	2 (12-27)	12
	Medium	40 (51-142)	0	0	40
	Large	11 (153-417)	0	0	11

development of agriculture, animal husbandry and fisheries with emphasis on lac production were continued.

A. INSECT CULTURE PROGRAMME

(a) LAC CULTURE

Trials and demonstrations of improved methods of lac cultivation on *palas* and *ber* trees belonging to the cultivators were continued. Necessary inputs like broodlac, *sutli* and insecticides were supplied and the pruning and other instruments like secateur, *phunki* hooks were loaned to the beneficiaries for seasonal use.

Sticklac Coupe

Baisakhi 1978-79 *ari* crop was harvested from 267 *ber* trees belonging to 46 cultivators of Hardag, Barguttoo and Saheda villages and an average yield of 2·89 kg sticklac per tree was obtained as against 1·10 kg from the traditionally operated trees. The trees were inoculated during October-November 1978 with an average rate of 2·22 kg broodlac per tree. No pest control measure was applied in this coupe. Although the crop was comparatively poor as compared to that of last year, an increase of 106·4 percent over the traditional method was recorded.

Baisakhi 1979-80 *ari* crop raised on 117 *ber* trees of the same coupe using average brood rate of 2·18 kg per tree during October-November 1979 was harvested during April-May 1980 and an average yield of 3·91 kg sticklac per tree was ob-

tained as against 1·18 kg from the traditionally operated trees. The crop in general was better than last year and an average increase of 231·0 percent over the traditional method was recorded.

Broodlac Coupe

Baisakhi 1978-79 cum *katki* 1979 crop was harvested from 351 *palas* trees belonging to 50 cultivators of all the four villages during October-November 1979 and an average per tree yield of 2·263 kg broodlac was obtained as against 0·540 kg per tree from the traditionally operated trees. These trees were pruned during April-May 1978 and inoculated at the rate of 0·625 kg broodlac per tree during October-November 1978 and no pest control measures were applied on them. On the whole, 319 percent increase in the broodlac yield was demonstrated.

Baisakhi 1979-80 cum *katki* 1980 crop from another coupe was harvested from 158 *palas* trees belonging to 25 cultivators of all the four villages during October-November 1980 and an average per tree yield of 2·90 kg broodlac was obtained as against 1·02 kg per tree from the traditionally operated trees. The trees were pruned during April-May 1979 and inoculated at the rate of 0·57 kg broodlac per tree during October-November 1979 and pest control measures were applied. This year average increase of 183·5 percent in the broodlac yield per tree was recorded.

Thus the improved technology was successfully demonstrated to increase the sticklac yield from 2 to 4 times and broodlac yield but the process of adoption was extremely slow. The constraints were identified as follows:

(1) Nearly 78 percent of the population belongs to backward and tribal communities with quite a low level of literacy. They are hesitant to adopt new technology and very often not ready to accept even free services and inputs, perhaps out of suspicion and distrust based on the past experiences.

(2) Heavy indebtedness, large scale land alienation and social factions keep their minds confused and perturbed. This impedes the acceptance and continuity of the package as a whole which requires regular attention.

(3) The *palas* trees are generally situated away from the homesteads of the lac growers and hence thefts are common. This acts as a serious deterrent in acceptance of the recommended practice of maintaining two coupe of this host for ensuring regular broodlac production year after year.

(4) Being the sole food crop of any importance the paddy crop received top priority. Since inoculation and *phunki* removal operations coincide with the paddy harvesting operations, the farmers prefer the traditional method involving less time and attention.

(5) Lack of ready money compels the farmers to cut their entire lac crop as *ari* in order to meet their immediate and pressing needs.

(b) APICULTURE

Training of 22 farmers in 3 villages was arranged in cooperation with the Khadi and Village Industries Board, Bihar during Jauary 1979. The trainees were provided with scientific hives as stipend and the old and new trainees picked up the scientific bee-keeping. During 1979, total 43 bee colonies were maintained, out of which 31 colonies were recorded to produce 140·5 kg honey. Average output of 4·5 kg honey per productive colony generated an annual income of Rs 65.38. Farmers exhibited enthusiasm about the programme and one artisan even fabricated his own hive and honey extractor.

During 1980 also total 48 bee colonies were maintained and 166 kg honey was produced from 34 colonies. Average output of 4·88 kg honey per productive colony was recorded in spite of severe drought conditions and Rs 73.23 per colony/year was earned by the bee keepers.

The marketing of the honey posed problems during 1979 and honey was sold in bulk at very low price. During 1980, bottling of honey in 1 kg bottles was introduced and all the honey was disposed at rates ranging from Rs 15 to 30 per kg.

(c) SERICULTURE

Resource survey and training of farmers in sericulture were initiated during 1980. Introductory lectures on *tasar* culture were arranged and free supply of a large number of mulberry cuttings and seedlings was arranged with the cooperation from State Industries Department, Bihar. Twelve farmers were selected for training in sericulture under TRYSEM scheme.

B. CROP PRODUCTION PROGRAMMES

(a) AGRICULTURAL CROPS

During 1979, six farmers were encouraged to purchase high yielding varieties of seeds, fertilizers and pesticides and to use them for improving their yelds advantageously, whereas no farmer ever used these inputs earlier. Four crop loans involving Rs 450 only were arranged through the Bank of India, Main Road, Ranchi for this purpose. Rock phosphate (Musurie Phos 62·25 tonnes was distributed free of cost for improving the soil reaction and fertility of the selected fields in the area with the cooperation from the State Agriculture Department, Bihar.

During 1980, two demonstrations of groundnut AK 12-24 and one that of '*Saket*' variety of paddy covering 1·24 ha area were conducted with the cooperation from State Agriculture Department, Bihar. Crop loan was arranged through the State Bank of India, Upper Bazar Branch, Ranchi for one farmer to enable him to undertake weeding operation in the demonstration field. The yields of groundnut and paddy were recorded to be 585 and 1083 kg/ha respectively.

(b) HORTICULTURAL CROPS

During 1979, total 145 papaya and 146 jackfruit seedlings were procured from the Forest Department, Bihar and distributed free of cost. In addition, 1000 seedlings of brinjal raised at this Institute were also distributed free of cost.

During 1980, thirteen backyard fruit garden each having 10 seedlings of guava (both gooty as well as seed propagated), *gulab jamun* and jack fruit were established with the cooperation from State Agriculture Department, Bihar and in addition, 49 fruit seedlings of mango, lemon, papaya and guava were also supplied. By the end of December 1980, on an average 62 percent of the planted seedlings were surviving. Total 510 cuttings and seedlings of mulberry were distributed and planted with a dual objective of supporting the silk culture and fruit production. Tapioca was also introduced and a large number of cuttings were distributed for planting. By the end of December 1980, on an average 42 percent survival was recorded.

(c) AGROFORESTRY

During 1979 in addition to the fruit species mentioned above total seedlings of *ber* (130 nos.) *eucalyptus* (240 nos.) as a bee forage and *bamboo* (124 nos.) were distributed free of cost with the cooperation from the Forest Department.

Similarly, during 1980, total seedlings of lac hosts including *palas*, *galwang*, *ber* and *kusum* (73), fodder species i.e., *ku-babool* and *sevari* (585), *eucalyptus* (960), as a bee forage and *bamboo* (7) were distributed free of cost with the cooperation from the Forest Department.

Arrangements were also finalized for afforestation of nearly 4 ha of wasteland through the Forest Department.

(d) ALLIED ACTIVITIES

During 1979, four crop loans and purchase of three pairs of bullocks and one kerosene operated irrigation pump arranged for improving crop production with the cooperation from the Small and Marginal Farmers Development Agency and Bank of India, Main Road, Ranchi.

During 1980, purchase of one more kerosine operated irrigation pump was arranged through the State Bank of India, Upper Bazar Branch, Ranchi and S.F.D.A.

(e) CONSTRAINTS

In addition to the general constraints mentioned under lac culture the following specific constraints in respect of crop production were identified.

(1) Grazing by the tamed animals was identified as a very serious deterrent to growing of *rabi* crops and raising of tree seedlings.

(2) Lack of sufficient underground water in the existing wells and limited number of irrigation structures and equipments.

(3) Non-availability of modern agricultural inputs within reasonable distance and easy reach of the farmer.

(4) Lack of ready money for the purchase of inputs and the prevailing malpractices and red tapism in the issue of land certificates necessary for obtaining Bank loans.

C. ANIMAL HUSBANDRY PROGRAMME

There was no exotic or improved animal of any kind in the area up to 1979. During 1980, various aspects of animal improvement were undertaken for the first time.

A very serious outbreak of blackquarter disease of cattle was averted through timely vaccination with the cooperation from the Animal Husbandry Department.

(a) POULTRY KEEPING

Three egg laying units comprising of 100 white Leghorn pullets each were started with the cooperation from the S.F.D.A. (Special Animal Husbandry), S.B.I., Upper Bazar Branch, Ranchi and Veterinary College, Ranchi. Health cover

and technical support was regularly arranged and the pullets attained maturity and produced up to 75 percent of the layer population. The activity sufferred serious setback due to prolonged statewide strike of veterinarians. Farmers were selected for training under TRYSEM scheme.

(b) SWINE HUSBANDRY

Thirteen pig breeding units comprising of 28 females and 3 males growers of pure Yorkshire breed were started with the cooperation of the agencies mentioned under poultry keeping. These units were started during July 1980. By the end of December, only 14 females (sows) and one male (boar) survived and attained maturity. Total 16 mortalities were recorded during the year.

(c) CONSTRAINTS

Following specific constraints in respect of Animal husbandry programmes were observed.

(1) The exotic animals are sensitive, delicate and susceptible to dogs and jackals etc. necessitating extra protection and stall feeding and round the clock watch and attention in addition to regular veterinary care. They are thus not fitting the temperament of the tribal population who are accustomed to maintain animals on grazing alone.

(2) Lack of money managing ability and cash holding capacity reflects adversely on the feeding and care of animals in spite of sufficient income generation.

(3) Irregular and discontinuous health cover.

D. FISHERIES

During 1980, training of 16 fishermen in scientific pisciculture was arranged with the cooperation from Fisheries Department, Bihar. One tank of nearly 0·2 ha area was excavated under food for work programme.

E. SOCIAL AUDIT

During 1979, total 20 small and marginal farmers were formally identified and registered with the S.F.D.A. for making them eligible for obtaining Govt. subsidies under IRDP and other programmes.

During 1980, another 102 farmers were identified and registered with the S.F.D.A. Total 62 needy persons were registered with the local Employment Exchange with the cooperation from the District Employment officer by arranging an employment camp in the area.

F. EXTENSION EDUCATION PROGRAMME

Regular meetings of the farmers once every month in each of the four villages were conducted and guest lectures and group discussions on various technological aspects of improved agriculture and animal husbandry were arranged in order to improve the ability of the farmers to accept the innovations.

During 1980, two communication centres were established in the area where regular contact with the farmers was maintained and various extension material was displayed.

Visit of nearly 100 farmers was arranged during *rabi* and *Kharif Kisan Melas* held at Ranchi Agricultural and Veterinary Colleges.

(Seasonal training in *rabi* and kharif crops production covering more than 100 farmers was arranged in the area itself.)

Training of 22 farmers in Bee keeping was arranged within the area and training of 16 farmers in fisheries was arranged at Dhurwa, Ranchi.

During 1980, one *Ratri Prasar Pathshala* (Night Extension School) was started by persuading village youth for imparting functional literacy and general awareness about the new farming practices. Non-availability of kerosene oil for lighting was identified as a major constraint in running this school.

(R. C. Mishra and D. C. Srivastava)

AGRONOMY AND PLANT GENETICS DIVISION

(a) RESEARCHES COMPLETED

2.1.5 (Old No. 2.3.3) Vegetative Propagation of *Kusum* (*Schleichera oleosa*)

The performance of *kusum* as a host for lac cultivation shows wide variation within the species. In addition, the slow growing habit of *kusum* tree, which takes about 20-25 years to attain the stage of lac inoculation, is a great deterrent in raising its systematic plantations for intensive lac cultivation. In order to overcome these drawbacks, the propagation of *kusum* through vegetative means with the aid of growth regulators to obtain plants of proven value and to multiply them within a short period was initiated in 1977.

Of the various propagation methods tried, namely, air layering, stem cutting and cincturing, success was achieved through air layering with the help of growth regulators. The application of growth regulators significantly influenced the rooting response wherein good callus formation and large number of root initials were observed but the control ones did not develop any roots at all. The highest rootage (87·0%) was found with the application of IAA+IBA at 100 ppm (Table 14). In regard to number of roots and root lengths also, the mixture of IAA+IBA was found better than the other treatments (Table 15).

Out of the 4 months, namely, March, April, May and June, the air layering carried out in June was found best in establishing maximum number of rooted air-layers (Table 14). In May and June, success was achieved with all the combinations of growth regulators. Successful air-layers were planted under field condition and their survival after one year of planting was found good in all the treatments.

This finding would help in the quick establishment of systematic plantations of *kusum* using air-layers from the trees of proven value i.e. high lac-yielding capacity as determined from past records.

(B. K. Purkayastha and Moti Ram)

TABLE 14 — EFFECT OF GROWTH REGULATOR MIXTURES ON THE ROOTING OF *kusum*

Treatment	Concentration (ppm)	Rooted air-layers (%)				Callusing
		March	April	May	June	
NAA+IAA	50	—	—	33	33	Fair
NAA+IBA	50	22	33	33	55	Good
IAA+IBA	50	—	22	33	44	Good
NAA+IAA	100	22	22	33	33	Good
NAA+IBA	100	—	11	33	44	Good
IAA+IBA	100	33	33	66	87	Very good
Control	—	—	—	—	—	Poor

TABLE 15 — ROOTING PERCENTAGE, AVERAGE NUMBER OF ROOTS AND TOTAL ROOT LENGTH PER AIR-LAYER OF *kusum* (*Schleichera oleosa*)

Treatment	Concentration (ppm)	Rooted air-layers (%)	Number of roots per air-layer	Total root length per air-layer (cm)
NAA+IAA	50	33	32	307·00
NAA+IBA	50	55	26	203·60
IAA+IBA	50	44	49	494·50
NAA+IAA	100	33	19	215·70
NAA+IBA	100	44	26	212·60
IAA+IBA	100	87	56	545·10
Control	—	—	—	—

(b) RESEARCHES ON HAND

2.1 Propagation and Management of Lac Host Plants

2.1.2 Management of *bhalia* for lac cultivation

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

The study was continued as per the technical programme reported earlier (A.R. 1978). *Bhalia* bushes raised in July 1978 showed second phase of growth till the end of June 1979. The data on plant growth characters as recorded prior to lac inoculation in July 1979 did not show any significant effect between the different systems of planting, whereas the combination of urea and SSP showed marked influence on plant growth (Table 16). These bushes were inoculated with *kusmi* brood lac in July 1979 for raising *aghani* 1979-80 crop. However, the crop was good at the initial stage but later on it was heavily infested by *Chrysopa* sp. and other lac predators.

Bhalia bushes which were then coppiced in February 1980 alongwith harvesting of lac, showed satisfactory growth till July 1980 and these bushes were again

TABLE 16 — EFFECT OF PLANTING SYSTEMS AND FERTILIZERS ON PLANT HEIGHT AND NUMBER OF TILLERS PER *bhalia* BUSH YEAR (1979)

System of planting	Plant height (cm)					Number of tillers/bush				
	Fertilizer					Fertilizer				
	F1	F2	F3	F4	Mean	F1	F2	F3	F4	Mean
Square	135	148	172	160	154	5·3	5·4	6·3	5·9	5·7
Quincunx	140	145	170	170	156	5·9	5·6	5·9	5·9	5·8
Single hedge	138	155	175	158	156	4·7	5·1	5·9	6·0	5·4
Double hedge	135	135	165	165	150	5·0	4·7	5·5	5·7	5·2
Mean	137	146	171	163	—	5·2	5·2	5·9	5·9	—
		System of planting		Fertilizer			System of planting		Fertilizer	
CD at 5%		N.S.		9			N.S.		0·548	
CD at 1%		N.S.		12·8			N.S.		0·7	

N.S.— Not significant.

put to use for raising *aghani* 1980-81 lac crop. As regards growth, similar trends were observed as reported above.

The condition of the lac crop during the period under report was good though some of the bushes got dried up due to extensive damage to the root systems by a white grub (*Holotrichia serrata*).

(B. P. Singh and B. K. Purkayastha)

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

Expt. 1 — *Effect of intercropping of perennial fodder grasses in mixed plantation of bhalia and galwang*

The experiment as laid out on randomized block design, was continued. During 1979 season, significant growth response was observed in both *bhalia* and *galwang* bushes in the plots where grasses were grown as intercrops which was due to the application of fertilizers and other cultural practices given to the intercrops (Table 17). The results are in conformity with the previous year's findings.

Of the 4 species of fodder grasses grown as intercrops, Dinanath (*Pennisetum pedicellatum*) recorded highest yield (523·6 q/ha) followed by *Pennisetum purpureum* (385·8 q/ha), *Andropogan gayanus* (192·4 q/ha) and *Brachiara brizantha* (139·7 q/ha). In 1980 also, similar trend was observed with respect to fodder grasses yield. *Bhalia* bushes were innoculated in July, 1980 for raising *aghani* 1980-81 crop. However, the development of lac crop was not satisfactory due to the poor growth of the plants.

Expt. 2— *Raising of tuber crops and rhizomes in mixed plantation of bhalia and galwang*

The experiment was continued as per lay out reported last year. During the period under report, the best effect on total shoot length of *bhalia* was found in the

TABLE 17 — EFFECT OF GROWING DIFFERENT GRASSES AS INTERCROP ON PLANT HEIGHT AND NUMBER OF SHOOTS OF *bhalia* AND *galwang* DURING 1979

Treatment	*Bhalia*		*Galwang*	
	Plant height (cm)	Shoots/ bush (no.)	Plant height (cm)	Shoots/ bush (no.)
Control	73·47	3·97	48·45	2·12
Pennisetum purpureum	116·97	5·37	53·65	2·80
Andropogan gayanus	94·37	4·62	52·22	3·20
Brachiara brizantha	104·32	6·62	61·40	3·12
Pennisetum pedicellatum	101·55	4·9	62·45	2·92
CD at 5%	20·492	1·286	8·502	0·436
CD at 1%	28·764	N.S.	N.S.	0·612

TABLE 18 — EFFECT OF INTERCROPS ON THE GROWTH ATTRIBUTES OF LAC HOST — *bhalia* AND *galwang* (YEAR 1979)

Treatment	*Bhalia* (*Moghania macrophylla*)			*Galwang* (*Albizzia lucida*)		
	Plant height (cm)	Branches/ bush (no.)	Total shoot length/bush (cm)	Plant height (cm)	Branches/ bush (no.)	Total shoot length/plant (cm)
1. Tapioca	155·77	6·10	1858·00	117·88	4·11	409·33
2. Sweet potato	197·66	24·99	4452·00	172·77	10·21	1060·66
3. Ginger	173·66	16·33	3268·66	134·77	7·99	693·33
4. Turmeric	183·44	15·44	3789·00	165·66	10·88	1481·66
5. Tapioca + ginger	177·41	8·33	2709·00	135·99	6·10	514·33
6. Tapioca + turmeric	169·99	14·44	2941·66	123·66	3·22	520·00
7. Sweet potato + ginger	205·55	15·44	3369·66	159·77	9·20	1491·66
8. Sweet potato + turmeric	194·55	18·44	4249·66	188·11	9·44	1619·66
9. Sweet potato + ginger + turmeric	191·74	21·10	4894·00	184·55	13·22	1126·66
10. Control	153·55	8·77	1094·00	99·88	1·88	177·33
CD at 5%	28·35	6·10	440·00	20·70	3·41	570·00

plots wherein sweet potato+ginger+turmeric were grown as intercrops whereas in case of *galwang* it was best with sweet potato+turmeric (Table 18). The treatment differences were found significant in both the cases.

These *bhalia* bushes were inoculated in July 1979 for raising *Aghani* 1979-80 lac crop. The *galwang* bushes will be utilized for lac cultivation after attaining

the age of 2 years. The yield of *aghani* 1979-80 lac crop, harvested from *bhalia* bushes, was very poor because of severe damage done by the predatory insects during the period of September and October 1979 though the settlement and the development of lac insect were good at the initial stage.

Of the 4 intercrops grown during 1979 season, the gross return was maximum (Rs 3710.00), with sweet potato+turmeric (Table 19).

The bushes coppiced, during harvesting of lac crop showed satisfactory shoot growth till July 1980 and these were again inoculated for raising *aghani* 1980-81 crop. During 1980, the total shoot length of both *bhalia* and *galwang* was maximum where sweet potato+turmeric were grown as intercrops (Table 20). The *aghani* 1980-81 lac crop on *bhalia* bushes was progressing satisfactorily till December 1980 in spite of the attack of predators for which control measures were adopted timely by spraying of insecticides.

During this season, the yields of all the intercrops, were very poor due to extreme drought conditions prevalent during the period of crop development. The gross return from lac+intercrops was, however (Rs 2051.00) when sweet potato+turmeric+ginger were intercropped within *bhalia* and *galwang* (Table 21).

Expt. 3 — *Lac cultivation on palas under mixed cropping condition with tuber crop rhizome and grasses*

The experiment was initiated in 1979 for growing tapioca, turmeric and Dinanath an annual grass as inter crops within and in between the rows of *palas*. The experiment was laid out in R.B.D. with 5 treatments replicated 4 times. The treatments are as follows:

T_0 = No intercrop

T_1 = Tapioca within the rows of *palas* bushes+turmeric around *palas*

T_2 = Dinanath grass in between the rows of *palas*+turmeric (around *palas* bushes).

TABLE 19 — YIELD AND ECONOMICS OF INTERCROPPING WITH LAC-HOSTS-*bhalia* AND *galwang* DURING 1979 YIELD OF INTERCROPS IN QUINTALS/ha

Treatments	Tapioca	Sweet potato	Ginger	Turmeric	Return from intercrops Rs/ha
1. Tapioca	61·20	—	—	—	3060·00*
2. Sweet potato	—	10·30	—	—	566·00
3. Ginger	—	—	5·40	—	1080·00
4. Turmeric	—	—	—	23·40	3510·00
5. Tapioca + ginger	28·40	—	1·80	—	1780·00
6. Tapioca + turmeric	36·90	—	—	9·90	3330·00
7. Sweet potato + ginger	—	10·30	1·40	—	846·00
8. Sweet potato + turmeric	—	9·90	—	21·10	3710·00
9. Sweet potato + ginger + turmeric	—	7·40	2·50	10·30	2452·00
10. Control	—	—	—	—	—

*Rate — Tapioca: Rs 50.00/q; Sweet potato: Rs 55.00/q; Ginger: Rs 200.00/q; Turmeric: Rs 150.00/q.

TABLE 20 — EFFECT OF INTERCROPS ON THE GROWTH CHARACTERS OF LAC-HOSTS-*bhalia* AND *galwang* DURING 1980

Treatment	*Bhalia* (*Moghania macrophylla*)			*Galwang* (*Albizzia lucida*)		
	Plant height (cm)	Branches/ bush (no.)	Total shoot length/bush (cm)	Plant height (cm)	Branches/ bush (no.)	Total shoot length/bush (cm)
1. Tapioca	169	6·55	1180	239	6·55	911
2. Sweet potato	177	7·66	1056	208	6·44	955
3. Ginger	156	6·99	1245	256	8·88	1233
4. Turmeric	188	8·22	965	229	8·00	1033
5. Tapioca + ginger	178	6·77	1102	294	8·55	1399
6. Tapioca + turmeric	174	8·21	1163	245	4·33	677
7. Sweet potato + ginger	178	8·77	1151	276	9·55	1333
8. Sweet potato + turmeric	188	8·77	1378	254	10·77	1488
9. Sweet potato + ginger + turmeric	186	9·10	1300	209	9·00	1099
10. Control	094	4·77	504	200	3·66	433
CD at 5%	9	2·11	385	053	3·86	385

T_3 = Dinanath grass in between the rows of *palas* and tapioca (within the rows of *palas* bushes).

T_4 = Dinanath grass in between the rows of *palas* and tapioca within the rows of *palas*+turmeric around *palas* bushes

Of all the intercrops grown during 1979, Dinanath recorded satisfactory forage yield (Table 22). The yield of tapioca and turmeric were badly affected due to inadequate rainfall. The maximum gross income (Rs 6666.00/ha) was obtained from the plots in which Dinanath grass+tapioca+turmeric were grown.

Palas bushes under each treatment were divided into 3 coupes as the cultivation of lac on them would be carried out under the standard 3 coupe system i.e. one for raising the *baisakhi ari* and the other two for *baisakhi*-cum-*katki* brood crop in alternate years. In each treatment, two sets of *palas* bushes, coppiced in April 1980, were innoculated to raise both the *baisakhi* 1980-81 *ari* and *baisakhi* cum-*katki*, 1980-81 brood crop. The development of lac insects was satisfactory till the period under report.

During 1980 also, Dinanath recorded satisfactory yield and the gross income of Rs 6550.00/ha was obtained from the plots inter-cropped with Dinanath grass+tapioca+turmeric (Table 23).

(B. K. Purkayastha, B. P. Singh and Moti Ram)

2.1.4 Role of plant growth regulators on the growth of lac host plants

Expt. 3 — Effect of plant growth regulators on ber

Ber plants were coppiced in May 1979 to train them into bushes and shoots developed therefrom were given foliar spray of NAA and GA_3 separately at

TABLE 21 — YIELD AND ECONOMICS OF INTERCROPPING WITH LAC-HOST-*bhalia* AND *galwang* DURING 1980

Treatments	Yield of intercrops in quintals/ha				Yield of lac kg/ha	Return from intercrops Rs/ha	Return from lac Rs/ha	Total gross return Rs/ha
	Tapioca	Sweet potato	Ginger	Turmeric				
1. Tapioca	17·8	—	—	—	38	890·00*	152·00*	1042·00
2. Sweet potato	—	8·6	—	—	54	430·00	216·00	646·00
3. Ginger	—	—	3·2	—	50	640·00	200·00	1460·00
4. Turmeric	—	—	—	10·4	56	1560·00	224·00	1544·00
5. Tapioca+ginger	20·4	—	1·5	—	32	1260·00	128·00	643·00
6. Tapioca+turmeric	23·4	—	—	1·0	36	1320·00	144·00	1669·00
7. Sweet potato+ginger	—	5·1	1·3	—	74	515·00	296·00	936·00
8. Sweet potato+turmeric	—	7·5	—	7·8	70	1525·00	280·00	1820·00
9. Sweet potato+ginger+turmeric	—	6·2	1·9	7·1	74	1755·00	296·00	2051·00
10. (No intercrop)	—	—	—	—	30	—	120·00	120·00

*Rate — Tapioca: Rs 50.00/q; Ginger: Rs 200.00/q; Sweet potato: Rs 50.00/q; Turmeric: Rs 150.00/q; Lac: Rs 400.00/q.

TABLE 22 — YIELD AND GROSS INCOME PER ha FROM INTERCROPS GROWN WITHIN *palas* BUSHES DURING 1979

Treatment	Dinanath grass	Yield in q/ha		Gross income Rs/ha
		Tapioca	Turmeric	
No intercrop	—	—	—	—
Tapioca + turmeric	—	8·588	3·186	904·00*
Dinanath + turmeric	364·021	—	2·291	5803·00
Dinanath + tapioca	409·003	2·915	—	6280·00
Dinanath + tapioca + turmeric	413·585	2·395	2·291	6666·00

*Rate — Tapioca: Rs 50.00/q; Turmeric: Rs 150.00/q; Dinanath fodder grass: Rs 15.00/q.

TABLE 23 — YIELD AND GROSS INCOME PER ha FROM INTERCROPS GROWN WITHIN *palas* DURING 1980

Treatment	Yield in q/ha			
	Dinanath	Tapioca	Turmeric	Gross income Rs/ha
No intercrop	—	—	—	—
Tapioca + turmeric	—	13·33	3·15	1139·00*
Dinanath grass + turmeric	414·8	—	1·08	6384·00
Dinanath grass + tapioca	401·5	0·83	—	6064·00
Dinanath grass + tapioca + turmeric	419·8	2·04	1·01	6550·00

*Rate — Tapioca: Rs 50.00/q; Turmeric: Rs 150.00/q; Dinanath fodder grass: Rs 15.00/q.

TABLE 24 — EFFECT OF PLANT GROWTH REGULATORS ON *ber* DURING 1979-1980

Treatment	1979		1980	
	Plant height (cm)	Diameter of stem (cm)	Plant height (cm)	Diameter of stem (cm)
NAA 40 ppm	148·8	1·49	1·42	6·05
NAA 80 ppm	160·0	1·70	1·45	6·75
NAA 160 ppm	138·9	1·21	1·43	6·35
NAA 320 ppm	114·0	1·13	1·58	1·15
GA 20 ppm	135·9	1·25	1·47	6·45
GA 40 ppm	109·1	0·91	1·34	7·35
GA 80 ppm	134·7	1·25	1·23	4·80
GA 160 ppm	123·7	1·21	1·83	8·40
Control	124·0	1·11	1·02	4·20
CD at 5%	—	—	0·03	0·40

different concentrations. The growth characters with respect to plant height, and diameter of the shoots were found best with NAA at 80 ppm (Table 24) as compared to the control. The results were in conformity with the findings reported last year.

The bushes were again coppiced in May 1980 and the application of growth regulators on the freshly developed shoots was repeated. The bushes treated with GA_3 at 160 ppm showed best results with respect to growth characters (Table 24). However, this result differed with the earlier findings. The *baisakhi* 1980-81 lac crop grown on these bushes were progressing well till the period under report.

Expt. 5 — *Effect of* GA_3 *on kusum* (*Schleichera oleosa*)

The study was continued with the lay out as reported earlier (A.R. 1978). Two sprayings of GA_3 and urea alone and in combinations, at different concentrations were given at fortnightly intervals on the newly emerged sprouts of *kusum* pruned in January 1979.

Of all the treatments tried, the application of foliar spray of GA_3 (80 ppm)+ urea (1·0%) induced maximum shoot length as compared to the control (Table 25). The plants were inoculated with lac in July for raising *aghani* 1979-80 crop. Later on, the lac crop was badly affected due to severe damage by predatory insects.

The study was repeated in 1980 with the same schedule of treatments. Maximum shoot length (Table 25) was observed with the treatment of GA_2 (80 ppm)+urea (1·0%) and the results were in conformity with the earlier findings.

TABLE 25 — EFFECT OF GA_3 AND UREA ON *kusum* DURING 1979 AND 1980

Treatment	1979		1980	
	Average shoot length/plant (cm)	Diameter of shoots (cm)	Average shoot length/plant (cm)	Diameter of shoots (cm)
GA_3 20 ppm	63·77	2·30	0·51	1·53
GA_3 40 ppm	86·66	2·45	0·57	1·61
GA_3 80 ppm	82·10	2·50	0·70	1·70
Urea 0·5%	67·77	2·10	0·80	1·85
Urea 1·0%	79·44	2·12	0·80	1·63
GA_3 20 ppm + urea 0·5%	64·77	2·20	0·60	1·81
GA_3 20 ppm + urea 1·0%	90·88	2·43	0·60	1·59
GA_3 40 ppm + urea 0·5%	61·44	2·30	0·72	1·45
GA_3 40 ppm + urea 1·0%	94·66	2·60	0·86	1·80
GA_3 80 ppm + urea 0·5%	95·10	2·45	0·90	1·45
GA_3 80 ppm + urea 1·0%	101·44	2·54	1·17	1·93
Control	60·11	1·75	0·49	1·24
CD at 5%	27·05	N.S.	0·11	N.S.

The development of *aghani* 1980-81 lac crop grown on these plants was good at the initial stage but later on the-crop was damaged due to attack of predators inspite of control measures adopted through spraying of insecticides.

(Moti Ram, B. K. Purkayastha and S. C. Srivastava)

2.2 Genetics and Breeding Studies

2.2.1 (Old No. 2.4.2) Possibility of interspecific crossing in *Moghania* species

Expt. 1 — *Effect of different dates of sowing and growth regulators on flowering*

The experiment was carried out in a split-plot design involving monthly interval of sowing from March to August for *bhalia* (*Moghania macrophylla*) as main-plot treatments. Spraying of three growth regulators alone and in combination at different concentrations were given as sub-plot treatment. The details of treatments were as follows.

M. macrophylla

Main-plot treatment — seed sowing months

(i) March 1978
(ii) April 1978
(iii) May 1978
(iv) June 1978
(v) July 1978
(vi) August 1978

Sub-plot treatments — Growth regulators

(i) TIBA — 250, 500 and 1000 ppm
(ii) MH — 500, 1000 and 2000 ppm
(iii) Cycocel-250, 500 and 1000 ppm
(iv) TIBA 250 ppm+cycocel 500 ppm+MH 2000 ppm

The comparative performance on the flowering of *bhalia* under different treatments revealed that plants raised from March and April 1978 sowing induced flowering up to middle of November 1979 whereas it continued up to middle of January 80 in other treatments. The effect of plant growth regulators at different concentrations showed no marked differences with respect to the duration of flowering time.

Since the effect of growth regulators on the duration of flowering was not significant during 1979, the experiment was modified during 1980 to study only the effect of sowing at monthly intervals. A set of *bhalia* plants was raised by direct sowing of seeds at monthly intervals from April to August 1980. The flowering in any treatment, however, did not take place during the year under reports.

Expt. 2 — *Effect of pinching, topping, and growth regulators on M. macrophylla*

This experiment was continued on fresh set of *bhalia* plants raised in July 1978 in split-plot design replicated 3 times. The experimental lay out as proposed earlier (A.R. 1978) was modified with the addition of two extra treatments namely, four times topping and four times pinching under main-plot treatments and one

growth regulator, cycocel under sub-plot treatment. Thus, the treatments tried were as follows.

Main-plot treatments

(i) Pinching of inflorescence
(ii) Topping of apical twigs

T_0 = control
T_1 = one time topping
T_2 = two time topping
T_3 = three time topping
T_4 = four time topping

P_1 = one time pinching
P_2 = two time pinching
P_3 = three time pinching
P_4 = four time pinching

Sub-plot treatments — spraying of growth regulators

H_0 = Control
H_1 = NAA at 250 ppm
H_2 = NAA 500 ppm
H_3 = Cycocel (ecc) at 30 ppm
H_4 = Cycocel (ecc) at 60 ppm

Three sprayings of growth regulators were given after 10 days of first topping at monthly intervals on each of the topping and pinching sets of plants during July to October 1979.

The observations as recorded during the period under report showed that the flowering period in all the treatments of pinching and topping (except one time pinching) was delayed upto the month of February 1980, which coincided with the fresh flowering period of *M. chappar*. The flowering time was also delayed with the use of growth regulators but it was not same as observed in case of pinching and topping. Similar results were obtained during 1980 also.

Crossing in Moghania species

About 500 crosses of *Moghania macrophylla* and *M. chappar* and their reciprocals were carried out in between 7.30 and 9.30 a.m. The crossed buds were shed after 8-10 days of pollination.

Expt. 3 — *Floral biology of Moghania* sp.

The stigma of *M. chappar* was found receptive right from 12 hr before dehiscence to 12 hr after dehiscence under temperature ranging between 21·1 and 24·4°C and R.H. 52-58 percent. The length of pollen tube varied from 30·72 to 143·36 μ during the receptivity period (Table 26).

The stigma of *M. macrophylla* tested under field condition by artificial hand pollination *in vivo* revealed that the stigma became receptive 38-40 hr before anthesis and the pollination before 24-26 hr of anthesis was found suitable for 60 percent fertilization at 22·2 to 29·5°C and 100 percent R.H. (Table 27).

(S. C. Srivastava and Moti Ram)

TABLE 26 — RECEPTIVITY OF STIGMA IN *Moghania chappar*

Temperature (0°C)		R.H. (%)	Sampling hr	Receptivity of stigma (pollen tube growth in stigmatic tissue)	
Max.	Min.				
22·2	21·1	50	30	before dehiscence	—
22·7	21·1	52	24	do	—
22·2	21·6	54	18	do	—
23·3	22·7	57	12	do	61·44 μ
24·4	23·3	58	6	do	143·36 μ
24·4	22·7	58	—	at dehiscence	113·04 μ
23·3	23·3	57	6	after dehiscence	51·20 μ
23·3	23·3	58	12	do	30·72 μ
23·9	23·3	54	18	do	—
23·9	23·3	55	24	do	—

TABLE 27 — RECEPTIVITY OF STIGMA IN *Moghania macrophylla* BY POLLEN GERMINATION *in vivo* DURING 1980

Temperature (0°C)		R.H. (%)	Pollination (hour)	Stigma receptivity		Pod formation (%)
Max.	Min.					
32·0	22·7	82	60-62	before anthesis	−	
33·0	23·8	85	46-48	do	−	
33·0	23·8	85	38-40	do	+	initiated
29·5	22·2	100	24-26	do	+	60
25·0	22·2	97		at anthesis	+	40
25·0	22·2	97	8-10	after anthesis	−	

+, receptive; −, non receptive.

2.2.2 (Old No. 2.4.3) Selection for better performance of *Moghania macrophylla* as a lac host for *kusmi* strain of lac insects

Expt. 1

Best and poorest lac performer raised in progeny rows for both *aghani* and *jethwi* crops (A.R. 1978) were growing satisfactorily till the end of 1979. The plants raised for growing *aghani* 1979-80 crop were inoculated during July, 1979. The crop was however, damaged by lac predators, *Eublemma amabilis*, *Holcocera pulverea* and *Chrysopa* sp. in spite of taking control measures.

The set of plants raised for *aghani* crops were pruned during January 1980 and inoculated during July 1980 to raise *aghani* 1980-81 crop. The lac crop was developing well till the end of period under report. However, more than 30 percent plants died due to the damage in root systems by a white grub. The remaining plants were bagged individually and the seeds were collected for further studies.

Expt. 2 — *Study of genetics of bhalia*

Heterogenous population of *bhalia* plants raised in 4 replications was inoculated during July 1979 for *aghani* 1979-80 crop. Ten plants, selected at random from each of the replications, were marked for their critical observations. The lac crop was heavily damaged by the lac predators *Eublemma amabilis* and *Holcocera pulverea* and therefore, the lac could not be obtained.

Expt. 3 — *Study of extent of cross pollination in bhalia*

Seeds collected from both green and greenish tinged podded plants were sown in nursery beds separately and the seedlings were transplanted in the field in alternate rows. The plants did not flower till the period under report.

(P. Kumar, S. C. Srivastava and D. C. Srivastava)

2.2.3 (Old No. 2.1.1) Evaluation and improvement of *arhar* varieties for lac yield as well as pulse production

The experiment was continued as per the lay out reported last year (A.R. 1978). Observations on plant attributes like girth of primary branch, pod length, grain yield and number of grains per pod were recorded for inoculated and uninoculated sets of plants raised during June 1978 (Table 28). It was revealed that grain yield reduced due to lac cultivation in all the varieties tried, except varieties No. 3570 and T-21. Plants carrying lac crop started dying during April due to extreme drought conditions and therefore, immature lac crop was harvested during April. Maximum lac yield per plant was observed in the varieties ICP Nos. 7188, 6986 and 6344 (Table 28).

During 1979, the same varieties/cultivars except Pant A_3 which was replaced by Pant A_2 were again raised in R.B.D. with 3 replications. Var. Pant A_2 did not germinate. Observations on various plant attributes namely, plant height, number of primary and secondary branches per plant at the time of flower initiation were taken. The plants were inoculated with lac during October 1979 to raise *baisakhi* 1979-80 crop. Some of the plants carrying lac crop started dying during summer months. The lac crop was not harvested during July 1980 and left for self inoculation to raise *baisakhi*-cum-*katki* crop. Plants survival up to lac crop maturity was better in ICP Nos. 6344 followed by 7119, and var. no. 3570 (Table 29). The maximum brood lac yield per plant was recorded from var. *Basant*. The Grain yield data could not be obtained as the flowers had shed due to adverse climatic conditions.

Eighteen varieties/cultivars (16 earlier and 2 new varieties *Bahar* and *Laxmi*) were raised during June 1980 in R.B.D. with 3 replications. Various plant attributes namely, plant height, number of primary and secondary branches, total shoot length and diameter of mainshoot per plant were recorded (Table 30). It was observed that the total shoot length and number of primary branches per plant were maximum in case of ICP No. 6344 and minimum in ICP No. 8501. Plants were inoculated during October, 1980 to raise *baisakhi* 1980-81 crop. The lac crop was growing well till the period under report.

(P. Kumar, B. P. Singh, S. C. Srivastava and R. S. Gokulpure)

2.2.4 Mutation studies on *arhar* in relation to lac and pulse production

Dry, dormant pure line seeds of *arhar* (*Assam* cv.) were irradiated with gamma rays at doses rarging between 10 and 50 KR. The treated seeds alongwith untreated ones serving as control were sown in the field during June1979 for

TABLE 28 — SCREENING OF *arhar* VARIETIES/CULTIVARS FOR VARIOUS PLANT ATTRIBUTES, GRAIN AND LAC YIELD (DATA RECORDED ON JUNE 1978 SOWN PLANTS)

Varieties/ cultivars	Girth of primary branches/(cm)		Pod length (cm)		Grain yield/plant (g)		Grains per pod (No.)		Sticklac yield/plant (g)
	Inoculated	Uninoculated	Inoculated	Uninoculated	Inoculated	Uninoculated	Inoculated	Uninoculated	
Assam	0·48	0·61	4·89	5·35	3·396	15·085	1·6	1·8	0·010
ICP No. 7197	0·58	0·59	5·29	5·51	16·677	61·644	1·9	2·5	0·023
Pant A 1	0·46	0·45	4·61	4·41	9·062	13·565	0·9	1·2	—
ICP No. 7188	0·60	0·69	5·75	6·15	11·453	20·945	1·6	1·8	0·033
ICP No. 7119	0·52	0·56	5·99	6·80	11·841	18·639	2·1	2·1	0·027
AS 29	0·55	0·46	6·56	5·81	9·762	22·562	1·4	0·9	0·019
ICP No. 3783	0·61	0·52	6·89	7·96	15·202	28·341	1·8	2·0	0·019
ICP No. 6443	0·53	0·45	4·28	4·56	17·730	34·091	2·2	2·3	0·020
K 35 6	0·55	0·56	4·66	4·98	28·466	43·967	2·2	3·1	0·019
ICP No. 6986	0·52	0·45	5·91	5·64	15·307	25·527	3·1	3·5	0·033
Basant	0·57	0·49	4·89	5·27	15·59	44·85	2·5	2·4	0·025
ICP No. 7035	0·60	0·60	6·28	6·86	9·88	14·67	2·4	2·7	0·021
ICP No. 6344	0·62	0·63	5·28	5·49	20·92	42·41	2·4	2·6	0·032
T-21	0·43	0·52	5·16	5·24	22·94	19·91	1·4	1·5	0·006
No. 3570	0·50	0·49	4·88	4·36	29·93	28·52	2·1	1·7	0·025
ICP No. 4704	0·58	0·58	4·97	4·69	28·52	49·18	2·1	2·3	0·027
2 E	0·59	0·56	4·45	4·36	42·65	53·69	3·2	3·1	0·023
Pant A 3	0·37	0·34	4·12	4·41	—	—	—	—	—
UPAS-120	0·33	0·38	4·39	5·65	5·40	13·19	1·1	1·3	—
ICP No. 8501	0·68	0·52	7·56	7·66	11·367	20·120	2·1	2·5	0·027

TABLE 29 — SCREENING OF *arhar* VARIETIES/CULTIVARS FOR VARIOUS PLANT ATTRIBUTES, SURVIVAL AND LAC YIELD (1979-80)

Variety/Cultivar	Plant height (cm)	Primary branches per plant (no.)	Secondary branches/ plant (no.)	Plant survival at lac crop maturity (%)	Brood lac yield/plant (g)
UPAS-120	81·80	7·50	1·50	12·2	340
Pant A-1	87·90	7·30	1·30	24·4	—
T-21	96·06	16·73	12·16	40·7	35
K 35/6	172·73	20·50	22·03	11·5	83
ICP no. 3786	157·70	12·73	15·60	41·8	88
3570	159·50	18·50	14·60	45·4	266
ICP no. 7197	148·40	14·56	14·16	29·0	100
ICP no. 8501	146·16	10·16	8·16	28·2	200
2 E	163·03	16·33	10·40	33·3	106
ICP no. 7188	173·03	13·26	14·90	37·5	125
ICP no. 6344	146·13	17·03	27·03	53·64	146
ICP no. 7119	174·23	13·03	12·36	51·2	166
ICP no. 6986	156·50	14·20	11·90	27·9	130
ICP no. 4704	166·76	20·76	13·60	30·7	84
ICP no. 7035	168·3	13·23	13·00	6·2	200
ICP no. 6443	176·13	19·33	15·70	31·2	86
AS-29	160·90	14·73	7·53	37·5	100
Basant	135·20	14·90	9·16	37·0	433
Assam	145·90	18·16	12·03	22·2	100
Pant A-2	No germination of seeds	—	—	—	—

TABLE 30 — SCREENING OF *arhar* VARIETIES/CULTIVARS FOR VARIOUS PLANT ATTRIBUTES (1980-81)

Sl No.	Name of variety/ cultivar	Height/ plant (cm)	Primary branches plant (no.)	Total shoot length (cm)	Secondary branches/ plant (no.)	Height of main shoot from where first primary branch starts (cm)	Girth of main shoot plant (cm)
1	ICP no. 7188	140	14·10	1050	27·58	19·23	2·17
2	Assam	137	15·63	1081	21·23	25·20	1·90
3	K 35/6	143	16·03	1108	17·76	23·76	1·87
4	ICP no. 3783	164	17·06	1240	15·60	23·43	1·92
5	ICP no. 4704	139	14·70	1026	15·46	23·16	1·89
6	ICP no. 7198	138	13·73	992	18·90	23·00	1·92
7	Bahar	139	12·93	899	13·50	23·63	1·80
8	Laxmi	164	15·38	1134	19·70	26·66	1·89
9	ICP no. 8501	151	10·96	837	13·36	28·46	1·29
10	7 S	150	16·26	1128	15·90	26·03	1·95
11	2 E	139	14·33	1130	17·26	24·40	1·96
12	T 21	150	13·46	1107	13·46	29·96	1·55
13	ICP no. 6986	151	12·76	1006	17·13	26·93	2·08
14	ICP no. 6443	138	12·90	868	13·73	26·06	1·89
15	No 3570	128	14·16	980	21·36	21·03	1·91
16	As. 29	145	14·83	1080	16·06	26·33	1·96
17	ICP no. 6344	153	17·76	1332	21·00	21·76	2·09
18	Basant	135	12·80	896	13·83	27·13	1·69

raising M_1 generations. The germination and survival percentage were recorded and found to decrease with the increase in doses (Table 31). Seeds collected from individual plant were sown during June 1980 in progeny rows for raising M_2 generation. Observations on plant attributes viz., plant height, number of primary and secondary branches and total shoot length were recorded prior to lac inoculation in October 1980 to raise *baisakhi* 1980-81 crop (Table 32). The lac insects were developing well till the period under report.

(P. Kumar)

TABLE 31 — GERMINATION AND SURVIVAL PERCENTAGE OF PLANTS RAISED FROM IRRADIATED *arhar* SEEDS IN M_1 GENERATION (1979)

Treatment	No. of seeds sown	No. of seeds germinated	Germination percentage	No. of plants survived	Survival percentage
Control	180	138	76·6	135	75·0
10 KR	180	123	68·3	121	67·2
20 KR	180	118	65·5	116	64·4
30 KR	180	95	52·7	99	55·0
40 KR	180	93	51·6	88	47·8
50 KR	180	83	46·1	90	50·0

TABLE 32 — FREQUENCY DATA ON PLANT ATTRIBUTES IN M_2 GENERATION OF *arhar* PLANTS PRIOR TO LAC INOCULATION

Character	Range	10 KR	20 KR	30 KR	40 KR	50 KR
Plant height (cm)	0-50	28	3	6	14	3
	51-100	145	85	138	185	143
	101-150	104	194	157	136	146
	151-200	20	150	73	43	92
	201-250	—	3	—	—	3
Primary branches (no.)	0-10	121	119	151	177	132
	11-20	77	155	114	143	139
	21-30	18	107	48	41	71
	31-40	3	11	1	2	29
	41-above	—	—	—	—	—
Secondary branches (no.)	0-20	68	140	123	84	113
	21-40	15	75	43	22	71
	41-60	10	42	16	7	62
	61-80	3	19	15	2	9
	81-100	1	3	3	—	—
	101-above	—	—	3	—	7
Total shoot length (cm)	0-500	184	117	179	2	140
	501-1000	62	130	101	137	89
	1001-1500	29	100	56	64	67
	1501-2000	7	62	30	36	63
	2001-2500	3	17	3	11	11
	2501-above	—	—	—	—	5

(c) RESEARCHES CONTEMPLATED

(1) Agricultural utilization of lac mud as manure
(2) Management of *putri* (*Croton oblongifolius*) for lac cultivation
(3) Utilization of *ber* for lac, tasar and fruit
(4) Standardization of Agro-forestry practices for raising high lac-yielding *knsum* through air-layering
(5) Induction of polyploidy in *ber* for improved lac productivity

(d) INSTITUTE PLANTATION

In the model demonstration unit of the Institute Plantation, transplanting of *kusum*, *palas* and *ber* seedlings was carried out within the rows of existing lac-hosts in order to develop new plantation replacing old ones. A mixed plantation of *bhalia* and *galwang* covering an area of 3000 sq. metre was established in one of the areas of the existing *khair* plot. Ten smaller units have also been laid out wherein *putri* (*Croton oblongifolius*), *sandan*, *Ziziphus rotundifolius*, *Ziziphus nummularria*, *Milletia extensa*, rain tree, *galwang* were planted. A 2½ feet wide path along the fence line was constructed to facilitate the guarding more efficiently. *Dhaincha* was grown in between spaces of rows of *kusum* trees as green manure crop and thereafter, ploughed in the soil to improve the soil texture. Subsequently Niger, an oil-seed crop was grown in August-September with the object of suppressing the weeds.

Construction of raised circular mounds around *kusum* and *palas* trees under coupe I was carried out. Most of the low lying marshy areas were developed and paddy and wheat were grown in these fields along with the lac-hosts on bunds. Two obnoxious weeds of prolific growth, namely, *Lantana camara* and *Stachyterpheta indica* were uprooted from the *palas* and half of the *khair* plots. A promising fodder grass (Dinanath) was grown in a portion of *palas* and *khair* plots and thereby not only suppressed the growth of unwanted weeds but also earned a substantial revenue therefrom. In addition, upkeep and proper management of the lac-hosts have been carried out.

The low lying and water-logged areas under *khair* and *palas* plots were developed during the period and paddy grown in these plots. The bunds, thus prepared, were utilized for growing *palas* and *putri* plants. *Palas*, *ber* and *kusum* seedlings were planted within the rows in the respective plots with the object of raising new plantation of these host species. A small pond was constructed in the south-west corner of the plantation for irrigation purposes. Sunhemp was grown in the *kusum* plot as green manure.

A portion of the water-logged areas under *khair* plot was developed by adopting soil-conservation and proper drainage measures to raise *ber* plants therein.

In connection with " International Year of the Child ", the Nutrition Garden laid out in September 1978, was extended for growing vegetable crops in both rainy and winter seasons of the year 1979. Various kinds of vegetable grown therein were sold to the staff members of the Institute. Large number of *papaya* seedlings were distributed among the members of the staff at nominal rate and about 100 papaya plants were also grown in the plantation. The total revenue from the plantation through sale of vegetables, paddy, etc. was Rs 11,863.13 and Rs 13,809.79 during 1979 and 1980 respectively.

(e) MIXED PLANTATION SCHEME AT CHANDWA

There has been no lac crop on *M. macrophlla* during 1979 due to the non-availability of *kusmi* broodlac.

M. macrophlla bushes (2000 nos.) were put under lac inoculation in July 1980 with *kusum* broodlac (300 kg) for raising the *aghani* 1980-81 lac crop. The progress of lac crop was very good till December, 1980 though it was infested badly with predators which could be efficiently controlled through insecticidal spray followed by hand picking of larvae.

About 600 *A. lucida* seedlings were planted in this season and the plants grown earlier have shown satisfactory growth.

CHEMISTRY DIVISION

(a) RESEARCHES COMPLETED

3.1.4 Separation and study of components of lac resin

The project was started with a view to separate and characterize various components of hard resin — the ether-insoluble portion of lac resin.

A comparative study was made on the isolation of hard resin from different types of seedlac (*palas*, *ber*, *kusum* and *jalari*) and it was found that the method of alcohol extraction followed by precipitation with ether, is most convenient for its preparation resulting in an yield of 72 percent. The chemical constants such as acid, saponification, hydroxyl and carboxyl values were, thereafter, determined and it was observed that there was hardly any difference in these values. This finding was further supported by TLC examination.

Palas, hard resin was fractionated by urea-complex formation method into three fractions namely, A, B and C (36, 40, and 22% respectively). As Fr. B was major, it was refractionated into B-1, B-2 and B-3 (7·2, 13·6 and 18 percent respectively). The physical and chemical constants as well as TLC revealed sharp differences in their composition.

The fractions A, B-1 to B-3 and C were taken individually and partially hydrolysed with caustic soda (0·5 N. aq.) at room temperature. The resulting hydrolysed product, after acidification, yielded a water-soluble and a gummy mass (water-insoluble).

The water-soluble portion was extracted with ethyl acetate and pure acid like jalaric, *laccijalaric*, shellolic, *epi*-shellolic and a new aldehydic acid having molecular formula ($C_{15}H_{18}O_3$) were isolated from the extract.

From the water-insoluble gummy mass, the sodium, barium and zinc salts were successively prepared and pure acids like aleuritic, 10, 16-dihydroxyhexadecanoic, butolic and 16-hydroxy-hexadecanoic isolated.

The identification of the pure components was achieved by the conventional methods as well as by IR, UV and TLC techniques. Nearly 80 percent of the component acids of hard resin have been isolated and identified (Table 33).

The amount of aleuritic, jalaric and other terpenic acids in hard resin and its factions was estimated quantitatively by periodic acid oxidation, sodium sulphite addition and UV absorption methods respectively. Aleuritic acid was found to the extent of 10-16 and 30-41 percent before and after hydrolysis respectively.

TABLE 33 — APPROXIMATE COMPOSITION OF HARD RESIN

Sl No.	Name of acid with m.p. (°C)	Percentage in hard resin
1	Saturated straight chain-nonhydroxy acid	1·30
2	Aleuritic acid (100-101)	29·40
3	Butolic acid (56-57)	5·20
4	*w*-Hydroxy hexadecanoic acid (89-90)	3·90
5	10, 16-Dihydroxyhexadecanoic acid (76-77)	1·70
6	Jalaric acid (168-170)	25·75
7	*Lacci*-jalaric acid (164-165)	1·45
8	New aldehydic acid (liquid)	0·90
9	Shellolic acid (205-206) }	
10	*Epi*-shellolic acid (236-238) }	9·60
11	Other terpenic acid	
	Balance	20·80

Similarly, aldehydic acids were found to the tune of 10-17 and 30-37 percent before and after hydrolysis respectively. The present findings have further indicated that hard resin and its fractions are composed of aliphatic and terpenic acids in the ratio of 1:1 nearly.

The present study also deals with the isolation and identification of free acids present in lac resin. For isolation of free aldehydic acids, dewaxed lac (100 g) was taken and dissolved in sodium carbonate solution (10%) by stirring. The saturated sodium chloride solution was added to it slowly until the precipitation was complete. The filtrate was decomposed with dil. HCL and treated with excess of 2:4 DNPH reagent. The precipitate (4·4 g) was washed, dried and recrystallized from methanol. It melted at 204-207°C and seemed to be the hydrazone of aldehydic acids (jalaric/*lacci*-jalaric).

The isolation of free fatty acids was attempted by dissolving dewaxed lac (100 g) in alcohol (300 ml). The solution was successively extracted with *n*-hexane and altogether twelve fractions were collected. The TLC examination of the fractions revealed them to be the mixture of mainly non-mono-, di-hydroxy and keto acids. The fractions 4-12 being similar were pooled and extracted with petroleum-ether (40-60°C). A crystalline mass was separated out which was identified as butolic acid from the TLC examination and melting point (m.p. 56-57°C). The material left after the isolation of butolic acid and the fractions 1-3 were mixed together esterified and acetylated to obtain a mixture of the acetoxy esters. These esters were fractionated over a column of silica gel impregnated with silver nitrate whereby pure fractions of various component acids as mentioned in Table 34 were obtained. On the basis of the above study, it may be concluded that about 2·68 free aldehydic and 9·7 per cent free fatty acids are present in dewaxed lac.

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

3.1.5 Estimation of shellac in presence of other resins

The project was taken up with a view to evolve a method for the estimation of shellac in a mixture of other natural resins.

TABLE 34 — APPROXIMATE PERCENTAGE OF FREE ACIDS IN DEWAXED LAC

Saturated straight, chain lengths of C_{14}, C_{16} and C_{18}		0·30
Unsaturated straight, chain lengths of C_{14}, C_{16} and C_{18}		0·06
6-Ketotetradecanoic		0·45
6-Hydroxytetradecanoic		2·37
16-Hydroxy hexadecanoic		0·57
16-Hydroxy hexadec-9-enoic		0·77
Threo-9,10-dihydroxy of chain lengths C_{14} and C_{16}		1·37
Threo-9,10,16-trihydroxy hexadecanoic (aleuritic)		3·83
Aldehydic terpenic		2·68
	Total	12·40

The two major constituent acids of lac resin are aleuritic and jalaric, having vicinal hydroxyls and aldehydic functional groups respectively. At first, it was thought that the estimation of vicinal hydroxyls or aldehydic acids may be directly related to the amount of shellac present in the admixture. The other natural resins taken in the study for preparing admixture with shellac were *rosin*, *benzoin gamboge*, *kauri*, *pontianac* and *dragon's blood*. Most of these resins have measurable acid and hydroxyl values signifying them to contain carboxyl and hydroxyl groups. Some of them also contain vicinal dihydroxyl system. So, the idea of estimating shellac in terms of aleuritic acid was not attempted further.

The second choice left was to make the estimation through the aldehydic group of lac resin. It was found that the water-soluble portion of lac resin obtained by alkali hydrolysis, followed by acid decomposition gave positive test for aldehyde group whereas other nautral resins did not give test for the aldehydic group. An attempt was, therefore, made to estimate aldehydic acids from the aqueous portion obtained as above, utilizing sodium sulphite addition or visible absorption methods.

(a) *Sodium sulphite method*

The sodium sulphite addition is a well known standard method for the estimation of aldehydic acids (A.R. 1974-76, p. 80). Different types (*palas*, *kusum* and *ber*) of shellac (fresh and old) were taken for the study. An average value of 30 percent was obtained irrespective of their age or type.

The admixtures, taking different proportions of lac and other natural resins, were prepared and the above method was followed to estimate the percentage of aldehydic acids. The mixtures gave values nearly in direct proportion to the amount of shellac present in them.

(b) *Visible absorption method*

The method depends on the estimation of absorption of an alkaline solution of 2,4-dinitrophenyl hydrazone at 480 nm was adopted for the estimation of aldehydic acids in lac resin and its admixture with other natural resins (A.R. 1977 p. 41). An average value of 32 percent was found in lac resin whereas other natural resins did not give any value. Proportionate values were obtained for different admixture of lac with other natural resins.

(B. B. Khanna, N. Prasad and S. C. Sengupta)

3.2.4 Creation of unsaturation in aleuritic acid and its addition polymerization

An attempt was made to create unsaturation in aleuritic acid by bromination followed by reduction but with success. Therefore, aleuritic acid was reacted with unsaturated compounds such as allyl alcohol, crotonic acid and cinnamic acid in presence of conc. HCL (1%). The physical and chemical constants of the unsaturated derivatives are given in Table 35. Allyl aleuritate, aleurityl crotonate and aleurityl cinnamate were polymerized in benzene at 80°C using benzoyl peroxide (1%) as initiator under the inert atmosphere of nitrogen, the reaction time being 6 hr. The resultant compounds, obtained in small quantities, were of low molecular weights and were soluble in hot dioxane but insoluble in methanol, ethanol, ether, acetone, ethyl methyl ketone, benzene and xylene.

(A. Kumar and M. K. Misra)

TABLE 35 — CHRACTERISTICS OF THE MONOMERS (UNSATURATED ESTERS) AND THEIR POLYMERIZED PRODUCTS

Monomers	m.p. °C	Yield %	Iodine value		Acid value		Hydroxyl value	
			Theoretical	Experimental	Theoretical	Experimental	Theoretical	Experimental
Allyl aleuritate	53·55	58	73·78	70·05	Nil	Nil	489·3	462·0
Aleurityl crotonate	50-52	45	58·5	52·00	151·0	149·3	303·3	293·0
Aleurityl cinnamate	160	39	68·45	60·3	127·0	120·0	258·5	234·7
Product obtained after polymerizing allyl aleuritate		2·0	Nil	Nil	Nil	Nil	489·2	462·0
Product obtained after polymerising aleurityl crotonate	—	3·4	Nil	Nil	151·0	145·6	303·3	299·6
Product obtained after polymerising aleurityl cinnamate	—	3·0	Nil	Nil	127	117·6	258·5	243·6

3.3.9 Use of shellac in rocket fuel

Solid rocket propellants consist of mainly three ingredients, a polymeric binder, an inorganic oxidizer and a metallic fuel additive. The polymeric binder binds the discrete oxidizer particles, supplies fuel for combustion and imparts mechanical properties to the propellant. Since shellac possesses a number of desirable properties required in a good binder, its suitability as binder-cum-fuel for solid rocket propellant was studied. The firing tests were carried out at B.I.T., Mesra, Ranchi.

In the inital experiments, ordinary shellac when used did not serve the purpose as it produced propellants which had practically no flexibility. In successive experiments, a modified shellac, obtained by reacting shellac with ethylene glycol, dibutyl pthalate and phenolic resin, was used as a binder. Shellac propellants thus

obtained were smooth, uniform, compact and comparatively flexible. These propellants burnt smoothly and vigorously with high flame and left no ash.

During static firing experiment, a (150 g) charge of shellac propellant was found to burn smoothly and steadily without chuffing and a constant pressure which was noted by the continuity of the flame. A thrust of 16 kg was recorded.

When a bigger charge (300 g) was used in the above experiments, satisfactory performance could not be obtained due to poor flexibility of the propellant. The calorific value of the shellac propellant was 1134 calories/g.

To improve the flexibility, few more modified shellac compositions were prepared by reacting lac/hydrolysed lac with ethylene glycol and synthetic resins such as polyester, epoxy and phenolic, under different conditions of time temperature and proportions of reactants. The best results were obtained when equal proportions of lac, hydrolysed lac and ethylene glycol were heated together at 100°C for 10-16 min. and the resultant product mixed with oxidizer, additives and phenolic resin, was cured at 100°C for 18 to 24 hr. The propellant possessed good physical and mechanical properties including improved flexibility. These propellants burnt smoothly with non-smoky high flame and left no ash.

Comparative performance of shellac and P.V.C. propellants was also studied by burning both the propellants progressively in an isolated rocket chamber under similar conditions. It was observed that the shellac propellant burnt more vigorously and with a greater force than P.V.C. propellant indicating superiority of shellac propellant over P.V.C. propellant in respect of burning properties. Shellac propellents also have the advantage of high specific gravity and freedom from toxic gases over conventional propellant based on P.V.C.

The results show that solid rocket propellants having moderate flexibility and good burning properties can be prepared by using a modified shellac.

Since a separate project on shellac based rocket propellant was sanctioned by I.C.A.R. for B.I.T., Mesra, Ranchi, the work on this project was concluded in 1980.

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

3.4.6 Shellac based paint/perimer for the gas holders of gobar-gas plants

Gobar-gas plants are being popularized throughout the country as a cheap source of fuel/energy for household use. The gas holder is the main component of the plant and is fabricated from mild steel. Since the holder remains immersed in gobar-slurry, it gets corroded in a short period. Ordinary paints do not last for more than a few months under these conditions.

On enquiry, the Central Fuel Research Institute, Dhanbad informed that *p*H of the gobar-slurry in a gobar-gas plant remains between 7·8 and 8·4 and the gases evolved mostly comprise of methane and hydrogen. In addition, gas holder is exposed to weathering conditions. Shellac, though having many desirable properties suffers from some inherent drawbacks, such as poor resistance to water, alkali and weather. However, there is scope for improvement of these properties through suitable modification. A few modified lacs were tried for this purpose.

1. *Preparation of shellac-epoxy resin composition*

Dewaxed lac (100 parts) and epoxy resin (40 parts) were dissolved together in a mixture of butanol and xylene (70 parts). The solution was refluxed for 4 hr with simultaneous removal of water azeotropically. Thereafter, dicyandiamide (1 part) was added and refluxing continued for a further period of 15 min (composition 1).

The above product (100 parts) was diluted with same mixture of solvents (50 parts) pigmented with red oxide (60 parts) and ball milled for 16 hr (composition-1a).

2. *Preparation of shellac-linseed oil-glycerol-isocyanate composition*

Linseed oil (alkali refined 100 parts) was first reacted with glycerol (10 parts) using litharge (1 part) as catalyst at 220-30°C for 1 hr. The resulting glycerides were then combined with dewaxed lac (50 parts) by adding it portionwise at the same temp. for 1 hr. The shellac-linseed oil-glycerol combination (100 parts) was cooled and diluted with white spirit (40 parts) and xylene (10 parts). The resulting varnish was pigmented with lamp black (5 parts) and ball milled for nearly 20 hr. Cobalt naphthenate (1 part) and toluene di-isocyanate (TDI, 25 parts) were added to it and mixed thoroughtly (composition-2) before 15 min of application.

Performance test under laboratory conditions

Compositions (1a) and (1b) were applied on a good number of well prepared mild steel panels. After air drying for one week, some of the panels were baked (160°C for 30 min). These panels were then tested by dipping in gobar-slurry of required consistency under laboratory conditions. The slurry was changed periodically.

The composition (2) was applied as a top coat over the above pannels and also as a single coat without the use of any primer and tested similarly.

Following observations were made:

(i) Panels coated with compositions (1a) and (1b) baked at 160°C for 30 min. with a top coat of composition (2) withstood immersion test for a year.

(ii) Composition (1a) baked at 160°C for 30 min. and without a top coat of (2) also withstood immersion test for a year while composition (1b) failed.

(iii) Composition (1a) air dried with a top coat of composition (2) was lightly affected after 6 months while (1b) failed even earlier.

(iv) Composition (2) without a primer coat withstood the immersion test for a year.

(v) Composition (1a) and (1b) air-dried failed very early.

Plant trials of the compositions

With a view to test the performance of lac based paint/primer under actual working conditions, a mini-gobar-gas plant (capacity 1 CUM) was got erected in the Institute. Small areas of the gobar-gas holder, both from inside and outside, were properly cleaned and coated with compositions based on (i) shellac-epoxy resin and (2) shellac-linseed oil-glyceroltoluene diisocyanate and allowed to air dry for a week. A small area coated with (i) was given a top coat of (2) as well and air dried. Thereafter the gas holder was lowered into the pit and kept immersed in the gobar-slurry. Fresh gobar-slurry was fed into the plant everyday.

The results obtained under actual plant trials were in line with those obtained under laboratory conditions. It was observed that whereas the compositions based on shellac-epoxy resin failed after 2 months and if coated with a top coat in 6 months, the compositions based on lac-linseed oil-glycerol-toluene diisocyanate used alone withstood the immersion test up to one year without showing any signs of deterioration when applied either inside or outside of the gobar-gas holder even without the use of a primer indicating its suitablity for such a purpose.

In order to coat the whole surface of the gas holder and work out the coating power and economics of the composition, bigger lots of the lac-linseed oil-glycerol compositions were prepared and tested. The composition was found to work excellently well and was unaffected for a year.

Covering power and economics of the coating

The covering power of the composition developed works out to 12 sq. and the cost is Rs 40 per litre (December 1980).

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

3.5.2 Physico-chemical studies on lac for encapsulation

Encapsulation has found application in several areas e.g., industrial, commercial, domestic and farm and is a rapidly expanding technology.

Studies were undertaken on physico-chemical properties of lac to find its suitability as a wall material in encapsulation.

The solubility parameter (δ) of the shellac has been ascertained by three methods viz. (i) solubility, (ii) structural contribution due to atoms and bonds and (iii) intrinsic viscosity. It has been inferred that shellac can be used as a suitable Class III type of wall material having a number of polar groups. These findings would help in choosing a solvent/core/shellac wall capsular combination.

The polymer interaction parameter (μ) which indicates solvent power of a liquid polymer has been determined. It has been found that no segments to segment interaction takes place for hard and soft segments of shellac in ethyl or butyl alcohols. Ethyl alcohol is the most suitable solvent for organic phase separation, polymer incompatability and fluididized bed encapsulation processes.

The electrophoretic mobility of shellac has been determined at various *p*H ranges. It possesses net negative charge regardless to *p*H. It has been found that shellac behaves as a hydrophillic colloid and may be used in complex (*p*H) coacervation process of encapsulation.

Physico-chemical properties of aqueous shellac solution and hydrosols have been studied. The reversibility phenomenon has been found to take place. Both dewaxed and regular shellac are suitable for encapsulation purpose. However, regular shellac may be preferred from economic point of view.

Escape patterns of both regular and dewaxed shellac during dialysis have been studied. It has been found that the half escape time is almost the same for both type of shellacs. Optimum dialysis time for them has been ascertained from computation of resin concentration, *p*H and volume of diffusate. Any of these criteria works well and may serve as a new method of significance for determining the optimum time for completion of dialysis.

The nature of dispersed phase in shellac has also been studied from physico-chemical characteristics and spectral analysis. It has been found that membrane hydrolysis takes place during dialysis and hard resin of shellac which is responsible for acid colloid characteristics, is present mainly as a dispersed phase.

Studies on water sorption have shown that dialysed shellac sorps more moisture than shellac and the sorption is due to topo-chemical reaction. The chemisorption of water takes place due to accessibility of polar groups.

The specific permeability shows that films of shellac hydrosols are more permeable than shellac solution. Further, both sorption and permeability are interdependent and environmental factors have significant effect on them. These

findings may be helpful in making choice of the wall material and its modification required to be produced according to the weather conditions.

From the above studies, it may thus be seen that shellac can be used as a suitable wall material for encapsulation.

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

3.6.2 Effect of plasticizer on the electrical properties of lac

The effect of seven commonly used plasticizers viz., tricresyl phosphate (TPC), triphenyl phosphate (TPP), tributyl phosphate (TBP), dibutyl phthalate (DBP), dimethyl phthalate (DMP), dioctyl phthalate (DOP) and castor oil (COIL) on the dielectric strength of air-drying shellac varnishes (prepared from commercial dewaxed lemon shellac) has been studied. To investigate the effect of shellac-wax, the study was extended to varnishes prepared from Autoclave grade shellac (containing 3% wax) and *bhatta* shellac (containing 4·5-5·5% wax). Studies were also made with varnishes prepared from dewaxed shellac prepared in aqueous medium at the Institute. Shellac varnish (25-40% w/w) was first prepared by dissolving it in denatured alcohol (freshly distilled), filtered through muslin cloth and the plasticisers were added in different proportions on the shellac content. The varnsihes were tested as per IS:352-1973.

Study with dewaxed lemon shellac obtained from M/s Angelo Bros, Calcutta

A gradual increase in the dielectric strength of the varnishes was observed due to the progressive addition of all these plasticisers (A.R. 1979). The maximum increase was observed 20 percent of the plasticizers (Table 36).

The highest dielectric strengths for treated shellac varnishes was found to be 2·0 kV/milas compared to 1·0 kV/mil for plain DL shellac. The conditioning of the films obtained from all the plasticized shellac varnishes in 50 percent R.H. resulted in decrease in dielectric strength. The films prepared from TCP, DMP-, DBP- and TPP-treated shellac varnishes passed the test for flexibility. The addition of 20-30 percent DOP, COIL and TBP failed to impart flexibility in shellac films. Baking of the films, at 100°C for 15 min. resulted in brittleness which was probably due to the exudation of the plasticisers. The same was also

TABLE 36 — DIELECTRIC STRENGTH OF AIR DRYING SHELLAC VARNISHES CONTAINING DIFFERENT PLASTICIZERS (20%)

Plasticizer added	With dewaxed lemon shellac (kV/mil)	With ASK-grade shellac (kV/mil)	With dewaxed shellac prepared in aqueous medium (kV/mil)
TCP	2·0	1·53	1·97
TPP	1·5	1·12	1·47
TBP	1·6	1·12	1·6
COIL	1·57	1·23	1·59
DMP	1·7	1·36	1·75
DBP	1·7	1·37	1·71
DOP	1·4	1·28	1·53
Control	1·0	1·0	1·0

noticed on keeping the films below 20-25°C for 2 to 3 months prepared from plasticized varnishes having shellac content less than 30 percent while varnishes containing 30 to 40 percent shellac retained all the properties.

Among seven plasticizers studied, TCP, DBP and DMP were found to be suitable for their use alongwith shellac in electrical insulation because of their higher dielectric strength values and flexibility. The characterstics of these varnishes have been shown in Table 37. The films prepared from DMP treated varnish passed the test for resistance to transformer oil. Little improvement in the dielectric strength of the 20 percent DMP-treated shellac varnish was observed (1·7 kV/mil to 1·87 kV/mil) when 10 percent ethyl cellulose on (shellac content) was added.

Study with bhatta shellac

No appreciable change in the dielectric strength of shellac varnish was observed when 20 percent of the plasticizers were added in it. The films obtained, though flexible were not smooth and uniform and did not pass the test for resistance to transformer oil.

Study with ASK-grade shellac

It may be seen from Table 36 that the dielectric strengths of the varnishes prepared with ASK-grade shellac were low compared to those obtained from dewaxed shellac. The films obtained were smooth, uniform and flexible but did not pass the test for resistance to transformer oil.

Study with dewaxed shellac prepared in aqueous medium

This variety of shellac was found to be nearly identical to the commercial dewaxed lemon shellac in regard to their dielectric strength values. The colour of the varnish prepared with this shellac was, however, little darker than commercial variety.

Study with mixed plasticizers

Some studies were also made on the effect of using mixed plasticizers in shellac (DL) varnish (Table 38). Films prepared from castor-oil treated shellac varnish were found to be brittle. When castor oil was used alongwith TCP in the ratios of 1:2 and 1:3, the films were found to be flexible and higher dielectric strength values were also obtained compared to that of COIL treated shellac varnish.

Evaluation by actual users

Samples of TCP- and DMP-air drying shellac varnishes were supplied to local consumers and the same were found to be satisfactory for use on coils of electric motors which operate in normal atmospheric conditions.

(D. N. Goswami)

(b) RESEARCHES ON HAND

3.1 Chemistry of Lac/Constituents

3.1.2 Separation and study of components of lac wax

It has already been reported that lac wax on fraction with alcohol yielded three fractions namely, A, B and C (A.R. 1974-76). The fraction B (i.e., insoluble at 40°C) was investigated by preparative layer chromatography and two pure com-

TABLE 37 — CHARACTERISTICS OF AIR-DRYING DL-SHELLAC (40%) VARNISHES PRESENT ON CONTAINING DIFFERENT PLASTICIZERS (20%)

Sl No.	Characteristics	Shellac-TCP	Shellac-DMP	Shellac-DBP	Shellac-(DL)
1	Specific gravity	0·95	0·96	0·95	—
2	Viscosity at 27°C (centipoise)	33·7	31·8	30·3	—
3	Volatile matter (% by weight)	55	45	48	—
4	Drying time (min.)	60	60	60	30
5	Finish	Smooth and uniform	Smooth and uniform	Smooth and uniform	Smooth and uniform
6	Electrical strength at 27°C (kV/mil)	2·0	1·7	1·76	1·00
7	Flexibility of the film (minimum mandrel size 1/8″)	Passes	Passes	Passes	Fails
8	Clarity of the film	Clear	Clear	Clear	Clear
9	Compatibility with the thinner	Passes	Passes	Passes	Passes
10	Resistance to transformer oil	Fails	Passes	Fails	Fails
11	Behaviour of varnish on enamelled wire	Passes	Passes	Passes	Passes
12	Recommended use up to temperature (°C)	65-70	70-80	65-70	65-70

TABLE 38 — CHARACTERISTICS OF AIR-DRYING SHELLAC (DL) VARNISHES CONTAINING MIXED PLASTICIZERS

Plasticizer added	Dielectric strength (kV/mil)	Drying time (min)	Test for flexibility (minimum mandrel size 1/8″)	Clarity of the film
Shellac	1·0	30	Fails	Clear
TCPT+COIL (2:1)	1·9	60	Passes	Clear
TCPT+COIL (3:1)	1·9	60	Passes	Clear
COIL	1·57	60	Fails	Turbid
TCP	2·0	60	Passes	Clear

ponents having m.p. 80-81° and 68-71°C were isolated. Since this separation was cumbersome, the same fraction B has now been fractionated with ether into insoluble wax-fraction (B-1) and soluble (B-2) fraction. The ether-insoluble wax-fraction (B-1) was acetylated and refractionated with ether. The ether-soluble fraction B-1-1 which was presumed to be the acetylated alcohol, melted at 63-65°C

and gave a single spot (Rf value —0·33, solvent system-trichloroethylene: chloroform: acetic acid, 70:28:0·5 v/v). This was hydrolysed to the corresponding alcohol (m.p. 81-82°C, Rf value —0·08). The ether-insoluble fraction B-1-2, appeared to be a hydrocarbon melted at 79-80°C and gave a single spot (Rf value —0·85). It is being further identified.

The acetone-soluble wax fraction (A.R. 1974-76) was distilled at 25°C (0·1 mm/Hg pressure) and a pale oily product was obtained which was examined by TLC and found to be a mixture. It was further fractionated by sodium carbonate into two fractions (i) neutral and (ii) acidic. The neutral fraction was found to be a neutral mixture of three components (Rf values 0·13, 0·30 and 0·49 respectively). Attempts are being made to separate these three components by preparative thin layer chromatography.

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

3.1.6 Correlation of the properties of seedlac and shellac with age

Last year, *ber* sticklac (*baisakhi*, 1977-1978) procured from Bargutto was converted into seedlac and shellac by *bhatta* process. The samples were stored at room temperature and various physico-chemical properties at an interval of 6 months were determined. During the period under report, three more samples of sticklac viz., *palas* (*katki*, 1978) from Kundri, *kusmi* sticklac (*jethwi* 1979) from Hesal and *kusmi* sticklac (*aghani*, 1980) from Amjharia were procured, processed into seedlac and shellac and stored in gunny bags under room conditions.

The data for various physico-chemical properties determined in the samples are given in Table 39. A gradual lowering in the life under heat, flow, rate of filtration, dielectric strength, dissipation factor, conductivity and an increase in the cold and hot alcohol-insolubles was observed due to storage while colour remained mostly unaffected.

(B. B. Khanna, S. K. Saha, A. K. Ghosh, N. Prasad, D. N. Goswami and P. M. Patil)

3.1.7 Improvement in the method of isolating aleuritic acid from lac for maximizing its recovery

The study was initiated with a view to evolve a suitable and economical method for isolating aleuritic acid in increased yield. It was first desired to find out the cost of production of the acid by the conventional method of alkaline hydrolysis. Several lots (500 g each) of DL-shellac, *rangeeni* seedlac, *kusmi* seedlac and refuse lacs viz., *kiri*, *kunhi* and *molamma* dissolved in water (1500 ml containing caustic soda 100 g) were hydrolysed separately. Four replications were made in each case. It was observed that the rate of filtration of sodium aleuritate was very slow. This was improved upon by using muslin cloth instead of filter paper. The impurities were removed by filtering off the sodium aleuritate solution in hot condition. On cooling, the solution was acidified to yield crude aleuritic acid which was purified and recrystallized from ethyl acetate and activated charcoal. The yield of the crude acid in shellac and seedlac samples was 25 and 22 percent respectively. In case of refuse lacs, it varied between 19 and 21 percent (based on lac content).

The bulk preparation of the acid was then undertaken by making use of 10 kg of each sample. The acid, thus prepared, was identical to authentic *threo*-aleuritic acid in its TLC behaviour and melting point. The approximate cost of production of aleuritic acid per kilo has been found to be Rs 90, 105, 75 and 50

TABLE 39 — PROPERTIES OF SEEDLAC AND SHELLAC ON AGING

No.	Type of lac	Period of storage in months	Moisture (%)	Colour	Life under heat (min)	Flow (mm)	Cold alcohol insolubles (%)	Hot alcohol insolubles (%)	Rate of filtration (ml/20 min)	Intrinsic viscosity	T.L.C. Rf values (chloroform, methanol, acetic acid 90:10:2)	Dielectric strength (kV/mil)	Dissipation factor KHz	Conductivity at 100 KHz
1.	*Ber* seed lac (*baisakhi* 1977-78 Bargutto	Fresh	2·5	13	60	44	7·43	3·04	93·5	—	—	1 17	—	—
		6	1·77	12	59	40	8·85	3·02	93·0	—	—	1·1	—	—
		12	2·0	13	51	—	8·36	3·16	—	0·039	—	1·0	0·45	5·27
		18	—	13	50	38	9·3	3·68	87·0	0·030	—	1·0	0·40	4·5
		24	1·66	13	49	34	9·0	3·72	90·0	0·030	—	0·99	0·31	2·46
2.	Shellac from seedlac No. 1	Fresh	2·0	12	60	68	5·07	0·99	91·0	0·031	0·12, 0·36, 0·82	1·34	—	—
		6	1·52	12	60	66	—	0·98	85·5	—	—	1·31	—	—
		12	1·82	12	55	—	—	1·41	57·0	0·037	0·12, 0·36, 0·82	1·13	0·46	5·69
		18	—	12	54	52	—	—	28·0	0·035	—	1·1	0·43	5·31
		24	1·6	12	52	54	5·9	—	19·0	0·038	0·32, 0·54, 0·88	1·03	0·38	3·95
3.	*Palas* seed lac (*Katki* kundri 1978)	Fresh	1·9	9	54	44	7·27	3·7	94·0	—	—	—	—	—
		6	1·8	9	53	42	7·29	3·77	93·5	—	—	1·56	0·32	2·67
		12	1·61	10	45	33	7·1	4·53	95·0	0·031	—	1·15	0·28	1·89
		18	1·58	10	45	33	8·1	5·4	95·0	0·052	—	1·0	0·24	1·35
4.	Shellac from seedlac No. 3	Fresh	1·8	9·5	60	78	4·0	0·8	88·0	—	0·12, 0·39, 0·77	—	—	—
		6	1·72	9·5	59	75	4·03	0·8	86·0	—	—	1·82	0·30	2·35
		12	1·64	10·0	44	55	5·8	1·1	78·0	0·031	0·30, 0·55, 0·91	1·36	2·29	1·63
		18	1·5	10·0	44	56	—	—	35·0	0·04	0·52, 0·54, 0·88	1·1	0·23	1·24

— Contd

TABLE 39 — PROPERTIES OF SEEDLAC AND SHELLAC ON AGING — *Contd*

No.	Type of lac	Period of storage in months	Moisture (%)	Colour	Life under heat (min)	Flow (mm)	Cold alcohol insolubles (%)	Hot alcohol insolubles (%)	Rate of filtration (ml/20 min)	Intrinsic viscosity	T.L.C. Rf values (chloroform, methanol, acetic acid 90:10:2)	Dielectric strength (kV/mil)	Dissipation factor KHz	Conductivity at 100 KHz
5.	*Kusmi* seed lac (*Jethwi* 1979 Hesal)	Fresh	2·1	9	58	67	5·98	2·81	90·0	0·034	—	1·29	0·42	4·53
		6	1·5	9	54	60	6·77	2·77	92·0	0·037	—	1·1	0·36	3·39
		12	1·5	9	52	56	6·3	2·79	88·0	0·048	—	1·0	0·32	2·63
6.	Shellac from seedlac No. 5	Fresh	1·8	8	57	80	4·38	0·87	91·0	0·037	0·12, 0·35, 0·75	1·11	0·38	3·55
		6	1·54	9	54	75	—	0·9	88·0	0·036	—	1·03	0·36	3·31
		12	1·46	8	54	70	4·4	0·9	84·0	0·032	0·32, 0·54, 0·88	1·06	0·27	1·8
7.	*Kusmi* seedlac (*Aghani*, 1979-80 Amjharia)	Fresh	—	8	62	85	5·7	2·09	96·0	—	—	0·95	0·37	3·72
		6	1·3	8	59	70	6·6	2·10	92·0	0·042	—	—	—	—
8.	Shellac from seedlac No. 7	Fresh	—	8	60	90	4·2	0·84	83·0	—	—	0·95	0·36	3·49
		6	1·3	8	58	90	—	1·00	81·0	0·042	0·32, 0·54, 0·88	—	—	—

from seedlac, shellac, *kunhi* and *kiri* respectively based on prices prevailing in December 1980.

Attempts were also made to study the effect of the alkaline chemicals in different concentrations on the saponification of lac for maximizing the recovery of aleuritic acid. It was observed that the addition of sodium sulphite increased the yield of aleuritic acid to the tune of 3 to 5 percent. The strength of alkali had some effect on the yield of aleuritic acid. It was also observed that when the seedlac and water were taken in the ratio of 1:3 or 1:4 and 20 percent alkali added on the volume of water, the removal of wax at the initial stage was facilitated and the yield of crude aleuritic acid was 25 percent approximately.

In order to further increase the recovery of aleuritic acid, experiments based on the conventional alkaline hydrolysis and acid treatment followed by the alkaline hydrolysis were initiated. The mother liquor, obtained after separating sodium aleuritate during conventional hydrolysis, was acidified and the gummy mass, after thorough washing with water and drying, was treated with concentrated hydrochloric acid for 6-8 hr at water bath temperature to obtain chloroderivative which on alkaline hydrolysis for 8-12 hr at water bath temperature yielded a small amount of *erythro*-aleuritic acid. The study has given an encouraging information for maximizing the recovery of aleuritic acid from lac resin.

(S. C. Agarwal, B. C. Srivastava and R. N. Majee)

3.1.8 Spectrophotometric studies on lac

With a view to establish a correlation between the absorbance (in visible range) and colour index of lac, the absorption spectra of eight dewaxed varieties viz, DL shellac, Platina, Super Blonde, Blonde, Lunar, D.O., Deora and D.G. having colour indices from 0·6 to 35 and also bleached lac were investigated at different concentrations (solvent: ethyl alcohol) in the complete U.V. and visible region. In all cases absorption maxima at 225, around 290 and 425 nm and shoulders at 215 and 350 nm were obtained. For bleached lac, however, the absorption maximum and shoulder at 425 and 350 nm respectively were absent. The absorption bands at 425 and 350 nm were attributed to the colouring material present in shellac. The absorption bands at 215, 225 and 290 nm were interpreted to be due to the terpenic acids present in shellac.

An increase in optical density at 425 nm was observed within creased colour indices of shellac. A plot of optical density at 425 nm (concentration 10^{-3} g/ml) versus colour indices gave a straight line passing through the origin (Fig. 3). The following relationship was evaluted from the inverse of the slope of the above plot:

$$\text{Colour index} = 136{\cdot}9 \times \text{optical density}$$

The optical densities noted at other absorption bands did not show any such relationship with colour indices. The present study suggests that the above relationship can be used for a quick, convenient and more accurate determination of colour index of shellac compared to the existing method involving matching of colour of an alcoholic solution of lac with that of a standard iodine or other solutions.

Beer's law was found to be obeyed for the concentration range (10^{-4} g/ml to $1{\cdot}5 \times 10^{-3}$ g/ml). The plots of optical density observed at 425 nm with concentration for different shellacs also gave straight lines passing through the origin $E^{1\%}_{1cm}$ was evaluated from the slopes. The following relationship was obtained from a plot of $E^{1\%}_{1cm}$ versus colour index:

$$E^{1\%}_{1cm} = 0{\cdot}073 \times \text{colour index}$$

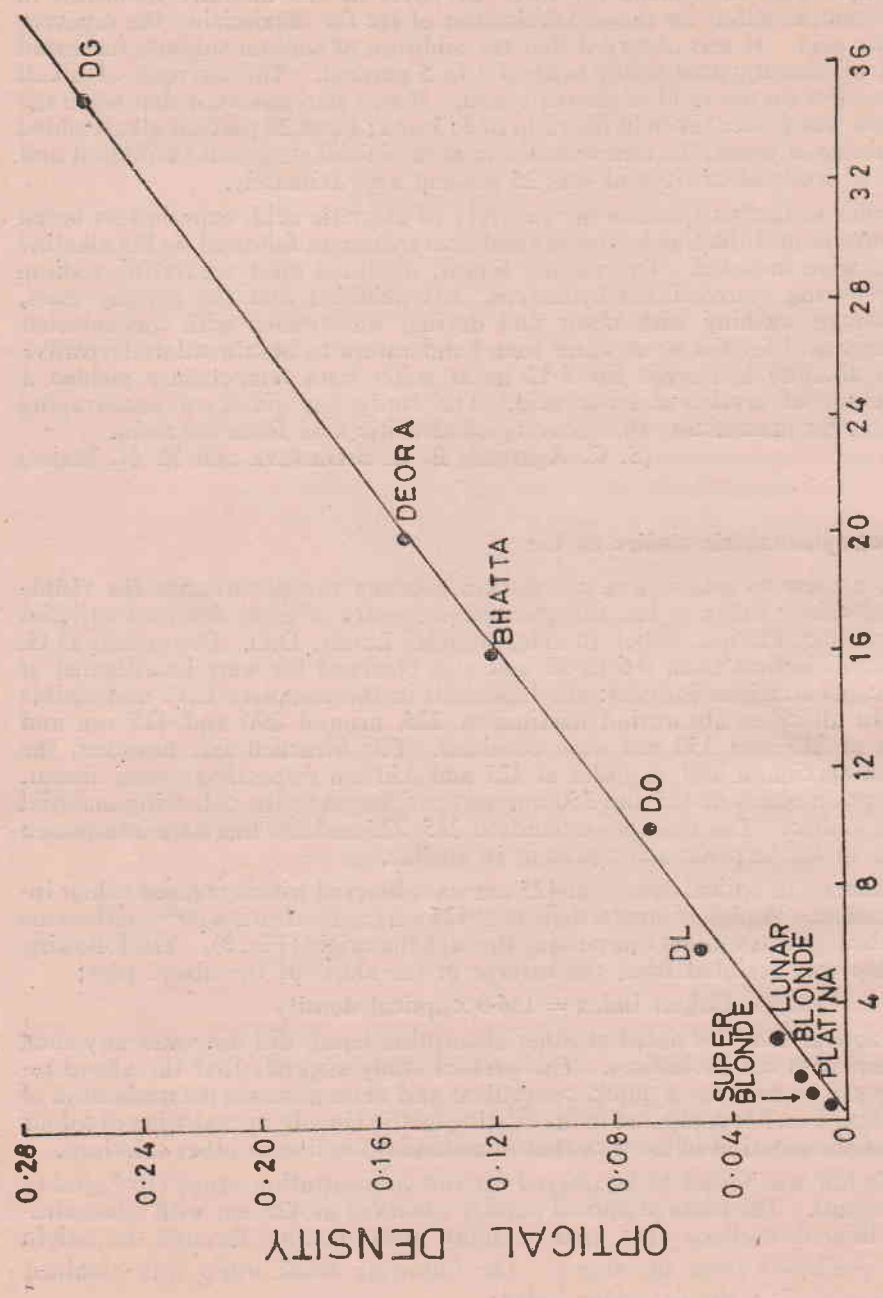

FIG. 3 — VARIATION OF OPTICAL DENSITY WITH COLOUR INDEX OF SHELLAC: OPTICAL DENSITY VALUES WERE RECORDED AT 425 nm (CONCENTRATION 10^{-5} g/ml)

Further, the absorption spectra of the hard and soft resins of lac and also of a few of their admixtures were investigated. The spectra of the soft resin were almost identical to those reported previously for DL shellac, the peak due to erythrolaccin was obtained at 435 nm while the shoulder at 215 nm obtained for DL shellac, was absent. For hard resin, two small additional peaks at 255 and 260 nm were noted in the U.V. region and the peak at 425 nm was not so sharp as observed in case of soft lac and parent shellac. The absorption spectra of 20:80 and 50:50 hard-soft resin mixtures were found to be almost identical to those of parent shellac.

It is well-known that shellac is a physical mixture of 70 parts of hard resin and 30 parts of soft resin. The absorption spectra of 70:30 hard-soft resin mixtures were, however, not identical to those of parent shellac in the U.V. region. Three small peaks at 255, 260 and 267·5 nm were obtained for 70:30 mixture in addition to those obtained for parent shellac. These results indicate that the spatial distribution of different polar groups in the mixture is not identical to that of parent shellac.

(D. N. Goswami, N. Prasad and R. N. Das)

3.2 Fine Chemicals from Lac

3.2.1 Synthesis of exaltone, isoambrettolide and prostanoidsynthon

(i) The preparation of Δ^9-hexadecene-1, 16-dioic acid from *threo*-aleuritic was reported last year. This acid (1·25 g) on treatment with thionylchloride yielded corresponding unsaturated dicholride (1·5 g), which was cyclized by high dilution principle and hydrogenated to yield exaltone (0·3 g).

(ii) *Threo*-aleuritic acid (5·0 g) was converted to trans-Δ^9-isoambrettolide (2·5 g) by the method developed earlier. *Erythro*-aleuritic acid (5·0 g) was first converted to *cis*-16-hydroxy-hexadec-9-enoic acid (liquid, 3·2 g) and then cyclized to *cis*-isoambrettolide (2·55 g).

(iii) Azelaic semialdehde (7·0 g) was obtained from *threo*-aleuritic acid (10·0 g) by treatment with sodium periodate in sulphuric acid. The above product on condensation with diethyl succinate in sodium ethoxide yielded unsaturated half ester. This was refluxed with HBr/AcOH to yield γ-lactone, which on treatment with polyphosphoric acid, afforded synthon 2-(ω-carboxy hexyl) cyclopentenone (2·2 g) as viscous liquid.

Adopting the procedures reported above, the following compounds were synthesized quantitatively:

(i) Exaltone (0·4 g) from aleuritic acid (2·0 g)

(ii) Trans-Δ^9-isoambrettolide (0·5 g) from *threo*-aleuritic acid (1·0 g)

(iii) Cis-Δ^9-isoambrettolide (0·45 g) from *erythro*-aleuritic acid (1·0 g)

(iv) Syhthon, a prostaglandin analogue (1·0 g) from ester of azelaic semialdehyde (3·2 g).

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

3.2.2 Syntheses of civetone and cyclic ureides from aleuritic acid

Many cyclic ureides have been found useful as sedatives and hyponotics. The present work was, therefore, initiated to explore the possibility of preparing cyclic ureides from aleuritic acid.

Heptadecane-1,17-dioic acid was first prepared from aleuritic acid. The ureides were synthesized following the standard procedure each from Δ^9-heptadecene-1,17-dioic acid and Δ^9-hexadecene-1,16-dioic acid by refluxing their diethyl esters with urea for 3 hr in ethanol containing sodium ethoxide. The ureides melted at 94-96°C and 88-90°C respectively. Both gave positive nitrogen test. The T.L.C. examination (solvent system: Ethyl acetate: acetic acid, 100:1, v/v) revealed them to be pure. The estimation of nitrogen is in progress.

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

3.3 Modification of Shellac/Constituents and Their Utilization

3.3.6 Ion-exchange resin from shellac

(i) In order to cut down the cost of production of the cation-exchange resin from shellac, attempts were made to replace resorcinol with cashew nut shell liquid (CNSL). The sulphonated shellac (1 part) was dissolved in sodium hydroxide (6%). Resorcinol and CNSL in ratios of 1:1, 1:2 and 1:3 were added to it. This was followed by the addition of formaldehyde (150 ml) slowly until a gel was formed. The gel was then broken, ground and heated in an oven at 100-105°C for 6-8 hr. A black hard resin of irregular shape was obtained. It was washed first with water and then extracted with spirit in a soxhlet. The resin was regenerated with HCL (N/10) for use. The properties of ion exchange resin are given in Table 40.

It will be observed from the table that as the CNSL percentage is increased, the resin shows a decrease in the yield and cation-exchange capacity. The price of the cation exchange resin prepared by using CNSL works out to be Rs 125/kg (approx.) as compared to Rs 275-300/kg (approx.) when only resorcinol is used.

(ii) Further studies were also made to eliminate the colour throw of the cation exchange resin, prepared earlier, which was found to impair its performance. The resin was first treated with sodium carbonate solution (5%), washed with distilled water and then equilibrated with sulphuric acid (5%). A little colour throw was still found to be present when tested with different organic solvents which could be overcome finally by extracting the resin in a soxhlet with spirit. A sample of one litre has been prepared for evaluation at the Central Salt and Marine Chemicals Research Institute, Bhavanagar, Gujarat.

(A. Rahman and B. B. Khanna)

TABLE 40 — PROPERTIES OF SHELLAC-CNSL BASED CATION-EXCHANGE RESIN

Properties	Ratio of resorcinol: CNSL			
	1:0	1:1	1:2	1:3
Moisture (%)	9·20	8·25	9·36	8·85
Yield (%)	65·0	48·0	44·0	41·3
Cation exchange capacity (meq/g)	4·38	3·25	2·82	2·45

3.3.8 Modification of lac/hydrolysed lac with glycols and dicarboxylic acids

Last year, the studies were carried out with shellac. This year, the work has been extended to hydrolysed lac.

(i) *Preparation of polyesters from hydrolysed lac*

Hydrolysed lac (obtained by hydrolysis of shellac under aqueous alkaline conditions) was reacted with ethylene glycol at 175+5°C for 4 hr. After removal of excess of ethylene glycol, the residue was reacted with four different dicarboxylic acids viz., adipic, maleic (as anhydride), terephthalic and phthalic acid in the proportions of 10 and 20 per cent (based on hydrolysed lac) at the same temperature for 2 hr. In this way, eight different esters were prepared and acid values determined.

(ii) *Reactions of polyesters with toluene-diisocyanate*

The above polyesters were dissolved in pure dry methyl ethyl ketone (to make a 25% solution) and reacted with toluene diisocyanate (30 and 40% based on the weight of the ester) at room temp. After thorough mixing and allowing to stand for 15 min., films were prepared on clean and dry glass slides. These films were found to be smooth, adherent, glossy and non-tacky. Air dried films (dried for one week) and baked films (baked at 150°C for 30 min.), thus prepared, were tested for water, acid and alkali resistance at room temp. The air-dried films showed good water and acid-resistance but poor alkali resistance. However, the baked films showed good alkali resistance. The testing of the adhesive properties of these compositions has also been initiated.

(B. B. Khanna and K. Mohan)

3.3.11 Modification of lac with unsaturated acids

The project was taken up with an aim to esterify shellac through its hydroxyl groups with unsaturated acids like maleic, acrylic, methacrylic, crotonic and oleic and then polymerizing these esters through condensation and addition polymerization techniques. It is expected that the compositions, so obtained, may have adhesion, and solvent resistant properties.

Shellac (100 g) was mixed with maleic acid (34·8 g), in 1:3 molecular proportion) and fused in a reaction kettle at 150°C for 18 min. The fused mass was taken out from the kettle in hot condition and allowed to cool. The physical and chemical constants of this product are being determined. Experiments were also carried out to react lac (alcoholic solution) with maleic/acrylic acid. Shellac (25 g) in methylated spirit (100 ml) was taken and maleic/acrylic acid (3%) were added to it. The mixtures were refluxed at water-bath temp. for 5 hr. The products, so obtained, are being studied for their surface coating and adhesive properties on different surfaces.

(N. Prasad, S. C. Agarwal, P. C. Gupta and A. K. Dasgupta)

3.3.12 Addition polymerization of shellac

In order to examine the possibility of addition polymerization, shellac (50 g) was dissolved in distilled water (500 ml) containing sodium hydroxide (4·0 g) and potassium persulphate (0·5 g) was added to it as an initiator. After stirring for several hours, the system was allowed to stand for 18 days at room temperature for the completion of the reaction. Thereafter, concentrated sulphuric acid was added with stirring until the upper liquid layer became transparent. The system was again allowed to stand for several days for settling and then the upper liquid layer was poured off. The sem-viscous product was washed with water and kept

for several days under water to leach out the soluble materials. After decanting off the supernatant liquid, the product was triturated thrice with water and dissolved in industrial spirit (500 ml). The yield was 31·52 percent.

In order to examine whether the polymerization has taken place, the unsaturation level of both monomer and the reaction product were measured by the Hubl's method. The iodine of the reaction product was found to increase which is difficult to explain.

(A. Kumar)

3.4 Use of Shellac and Modified Shellac in Surface Coatings

3.4.3 Studies on lac-oil combinations and their utilization

It was reported earlier that lac-double boiled linseed oil varnishes show very good drying characteristics and possess most of the desirable properties of a baking type insulating varnish.

In view of its overall good performance, four lots of this varnish (500 ml each, total 2 litres) were prepared to test special properties for defence use and also for evaluation by prospective consumers. The samples, so prepared, were tested for their electrical and other properties as a measure of quality control but it was observed that all the samples differed in their performance. This difference in performance was attributed to the frequent failure of electricity. The samples were, therefore, mixed together to obtain a uniform composition but the performance of the mixed samples was also not found upto the mark in respect of drying characteristics and miscibility with thinners and, therefore, the varnish could not be sent to consumers for their evaluation. A sample of the varnish which was supplied to a local consumer last year was applied in a 2 h.p. motor of an air compressor and has been reported to be working satisfactorily.

(S. Kumar, M. Mukherjee and D. N. Goswami)

3.4.7 Shellac paints for wood patterns

It was reported last year that paints based on lac-melamine formaldehyde resin (binder), titanium dioxide (hiding pigment) and spirit-toluene mixture (solvent) produce highly glossy films on wooden surface which showed good resistance to water and to the action of wet-sand.

This year, experiments were made to assess the suitability of lac-ethyl cellulose as binder for pattern enamels. Two paints amples based onloc-ethyl cellulose. were prepared under similar conditions. Uniform paints were obtained which on application on wooden surface produced hard, smooth and adherent films but the gloss of the film was comparatively inferior. In regard to resistance of the films to water and wet sand, more or less similar results were obtained. Since smoothness and gloss of the film play an important role in pattern enamels, samples of shellac paints of different shades were, therefore, prepared by using lac-melamine resin as a binder. It was observed that in the case of black shade, the gloss was the best. In other properties such as drying characteristics, adhesion to wooden surface, hardness and resistance to water and wet sand, no appreciable variation was noted.

Further, experiments were carried out to prepare paints based on lac-melamine resin-nitrocellulose (binder), alcohol toluene-ethylacetate mixture (solvent) and titanium dioxide (hiding pigment). Paint compositions, so prepared, when applied on wooden surface produced hard, smooth and adherent films and showed good resistance to water and to the action of wet sand. In regard to film proper-

ties, these paints behaved more or less similar to lac-melamine resin based paints excepting that these paints could also be applied by spraying.

Experiments were also carried out to study the effect of storage on the performance of lac-melamine resin paints. It was observed that even after one year storage, no change in any of the film properies such as gloss, hardness, resistance to water and to the action of wet sand took place. The drying time was, however, found to increase a little.

(S. Kumar and A. K. Dasgupta)

3.4.8 Studies on shellac esters and their utilization

Shellac esters, prepared by previous workers suffered from certain drawback such as dark colour, high viscosity, poor yield and inferior performance. An investigation was, therefore, undertaken to study the esterification of shellac under different conditions of temp. and time for the preparation of esters of good quality. Initially, the esterification of aleuritic acid with methanol was studied in the presence of conc. sulphuric acid. The products, obtained at different stages of reaction, were analysed by T.L.C. which indicated that the esterification is completed in 2 hr.

(M. Mukherjee, R. N. Majee, S. Kumar and S. N. Mukherjee)

3.5 Use of Lac for Encapsulation and Control Release

3.5.1 Coating of insecticides and pesticides with lac

It has been reported earlier that a microbial insecticide B.Th. encapsulated by the phase separation technique was supplied to the insect toxicologist of the institute for field trials but due to certain technical difficulties, he could not evaluate the same.

Efforts were, then made to get the encapsulated pesticides evaluated by the Agriculture Universities which have the necessary testing facilities. For this purpose, fresh samples of carbofuran, Phorate and Dimethoate were encapsulated by the mechanical process developed earlier (A.R. 1974-76). These encapsulated pesticides along with control have been sent to Kerala and Tamil Nadu Agriculture Universities for evaluation. The experiments have been planned on cow-pea using pea-aphids for assessing persistant toxicity of the lac encapsulated pesticides at Kerala Agriculture University. The results are awaited.

An enlarged sectional diagram of a machine based on centrifugal technique was also made for the fabrication of the equipment.

Samples of dialysed shellac and gelatin were sent to the Rodent Research and Training Centre, Jodhpur for palatability trials. They have reported that dialysed shellac which is used as a wall material for encapsulation of pesticides is acceptable to rodents. A bigger sample of dialysed shellac was prepared and sent to them alongwith gelatin and shellac for completing palatability screening trials.

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

3.5.3 Slow release chemically combined lac-based weedicides

Studies were undertaken to utilize lac, lac-mud and its by-products for the development of a slow release selective and pre-emergent type of the herbicide formulation for the control of *parthenium* and other weeds which pose serious threat to agriculture and animal husbandry.

The presence of hydroxyl groups in lac and its amorphous character provide scope for its chemical combination with 2,4-dichloro-phenoxy acetic acid (2,4-D)

to produce a suitable lac-based slow-release weedicide. Shellac was esterified with 2,4-D using direct fusion method in the molar proportions of 1:1 1:2 and 1:3. The results obtained so far have shown that the combination takes place through esterification between shellac and 2,4-D in 1:1 and 1:2 molar proportions.

Further, studies were undertaken to develop another method of combining lac with 2,4-D. Shellac was combined with acid chloride of 2,4-D through esterification. The acid chloride of 2,4-D was prepared by heating under reflux a mixture of 2,4-D (1 mole), thionyl chloride (1·5 mole) and dimethyl formamide (0·03 mole), for 3 hr. The removal of the excess of reagents under reduced pressure produced the acid chloride of 2,4-D having zero acid value.

Attempts were also made to esterify lac with 2,4-D in the homogeneous reaction system in the above molar proportions. Dioxane was used in the presence of pyridine. The solutions of the acid chloride of 2,4-D and shellac in the above solvent were heated under reflux for 3 hr. The reaction mixture was then concentrated to about half and hexane added (double the volume of dioxane) with vigorous stirring. The precipitate, collected by filtration, was dried to obtain the lac-2,4-D ester. The analytical studies of the reaction product revealed that the ester can be obtained in 1:1 and 1:2 molar proportions.

The samples of lac-2,4-D direct combination products in 1:1 and 1:2 molar proportions were sent for preliminary evaluation at IARI, New Delhi.

(B. C. Srivastava and S. C. Agarwal)

3.6 Electrical Properties of Lac and Modified Lacs

3.6.3 Curing behaviour of shellac-synthetic resin composites by dielectric measurements

The results of the investigation on the cold curing of shellac and melamine resin were reported last year. During the period under report, similar studies were made with epoxy resin (mol. wt 1000). Both shellac (DL) and epoxy resin were dissolved separately in a mixture of toluene and alcohol (1:1) and varnishes (25% w/w) were prepared. The blends were then prepared by mixing 80, 60 and 50 parts (by wt) of shellac varinish with 20, 40 and 50 parts of epoxy varnish respectively. The dissipation factor of the blends were measured after one hour of blending and this was continued for several days. For 60:40 and 50:50 shellac-epoxy blends, a rapid increase in the dissipation factor was observed up to three and six days respectively. Thereafter, no appreciable change was noted. The initial increase in the dissipation factor indicated an increase in the number of hydroxyl groups in the blends due to the interaction between the carboxyl group of shellac and epoxy group of the synthetic resin. However no appreciable change in the dissipation factor was noticed for the 80:20 blend.

The films, prepared from these blends, were not uniform. Blisters were found to be present presumably due to the difference in the rates of evaporation of toluene and alcohol from the surface of the films. The dielectric strength of the films could not be determined as the punctures occurred at a very low voltage through the blisters. In order to obtain the blister-free film, different combinations of the common solvents were tried. A mixture of methyl ethyl ketone (MEK) and denatured alcohol (distilled) (2:1) was found to be more suitable. The reaction between the functional groups of shellac and epoxy resin present in the blends (viz., 60:40, 50:50) in the mixed solvent was investigated by observing the change in the dissipation factor with time. The curing was found to be complete within six days after mixing. In the case of 50:50 blend, about 40 and 60% in-

crease in the dielectric strength was observed after two and six days of mixing as compared to DL shellac. The baking of the film at 100°C for 15 min. gave a dielectric strength (600 V/mil) which is lower than that of DL shellac (1·0 kV/mil).

Further, the cold curing of shellac and epoxy resin (mol. wt 1000) blends (70:30 and 50:50) was investigated in the solvent medium by studying the variation of conductivity (at 100 kHz) and specific viscosity with time at 30°C. For both compositions, an initial increase was observed. The conductivity versus time plot was found to be biphasic in nature with an inflection around the sixth day. The specific viscosity for both the blends was almost constant for a few days after attaining its maximum value around the sixth day. Thereafter, it showed an increase again with time (around 10th day). The rise in the conductivity could be due to an increase in the hydroxyl groups in the blends which arose from the interaction between carboxyl group of shellac and epoxy group of the epoxy resin. The increase in the specific viscosity suggests an increase in molecular weight of shellac, possibly due to the reaction stated above.

The study was then extended to epoxy resin of molecular weight 500. It was observed that the curing between shellac and epoxy resin was mostly completed within first six days after their blending. About 60% increase in the dielectric strength was noticed for the 50:50 shellac-epoxy blend after curing in the solvent medium for six days.

(D. N. Goswami and S. Kumar)

3.7 Standardization of Lac/Constituents

3.7.1 To prepare a standard for lac dye for use as a food colour

There appears to be a great demand for the water-soluble lac dye for use as a food colour. It was, therefore, decided to study its characteristics to lay down a standard for it.

Sticklac was crushed and washed with water to remove the water-soluble lac dye. Thereafter, the wash water was treated with lime. The calcium salt, so obtained, was converted into sodium salt by reaction with sodium carbonate. The resultant solution was passed through cation-exchange resin. The solution was then concentrated whereupon pure dye crystallized out.

In another set of experiments, the dye was prepared by a shorter route. Stick lac (*palas* and *kusum*) was washed with water. The wash-water was filtered through a cloth bag and filter paper. The filtrate so btained was passed through a cation exchange resin (Amberlite-120). The dye was crystallized after concentrating the solution at 60-65°C. Some of the characteristics determined are as follows:

Source of the dye	Solubility (%) in			Volatile matter (%) at 135°C	M.P.
	Cold water	Boiling water	Alcohol		
Palas sticklac	51·8	94·2	100	6·0	The product charred at 280°C
Kusum sticklac	52·0	95·0	100	6·5	

Since the solubility of this dye in cold water is low, attempts are being made to prepare the sodium salt of lac dye.

A sample of lac dye has also been sent to the Central Food Laboratory, Calcutta for carrying out the toxicity tests.

(B. B. Khanna, A. K. Ghosh and K. M. Prasad)

3.7.2 To prepare standards for different grades of lac wax

In order to revise the old IS specification for lac wax the present study was undertaken.

Three samples of lac was obtained from (I) lac dust (AI) (2) lac mud (AII) and (3) refined from lac mud (AIII) were procured from M/s Waxpol Industries, Tatisilwai, Ranchi. Their physical characteristics were studied according to the methods prescribed in IS:1699/1974. The results are as follows:

Samples No.	Acid value	Saponification value	Iodine value	Volatile matter(%) at 150°C	Resin content (%)	Appearance
A (I)	8·0	89·0	8·25	0·88	2·3	Pale yellow
A (II)	47·0	114·0	11·4	0·94	11·0	Dirty green
A (III)	48·0	125·0	15·0	1·15	10·0	Dirty green

The above results show that the acid, saponification and iodine values for the samples (A(II) and A(III) are very high which may be due to their high resin content or method of recovery of the wax.

(B. B. Khanna and K. M. Prasad)

(c) RESEARCHES CONTEMPLATED

1. Physico-chemical properties of the resin recovered from lac by-products.
2. Studies on anti-corrosive primers/paints for use on ferrous metals.
3. Biophysical studies on the interaction between laccaic acid and DNA.
4. Synthesis of queen bee pheromone and Juvenile hormone analogues from aleuritic acid.
5. Cation exchange resin from styrenated lac.
6. Studies on the use of lac as adjuvant in pesticide formulations.

D. TECHNOLOGY DIVISION

(a) RESEARCHES COMPLETED

4.1.1 Manufacture of shellac and dewaxed lac in aqueous medium

Shellac is generally prepared from seedlac by heat process and dewaxed lac by solvent process. In the latter case costly equipments and solvent (alcohol) are involved. Hence, attempts have been made to prepare both types of shellac

(regular and dewaxed) in aqueous medium, eliminating the by-products such as *kiri* and *pasewa*. The process developed is as follows:

Seedlac (10 mesh in a typical case having life 44-46 min., flow 45-48 mm and colour index 13·5-14 units) is dissolved in water (1:4) with sodium carbonate (8%) and sodium sulphite (3%) on the weight of seedlac at 85°C for half an hour. It is then filtered through cloth bag to remove the impurities (a). If dewaxed lac is to be prepared, the filtrate is again boiled and allowed to cool at room temperature in a tall form vessel. On cooling, a part of wax forms hard cake and floats on the surface which is scooped out. To the solution, paper pulp (7% on the weight of seedlac) is mixed and filtered through drill cloth bag under gravity (b). Sodium hydrosulphite (2%) on the weight of seedlac is added to either of solution (a or b), diluted to 5 percent lac content with water and finally precipitated with sulphuric acid (5%). The product is washed till free from sulphate ion. The precipitated material is boiled in water till it melts. The extra water is drained out and hydrolysed lac and recinoleic acid (2% each) are added to the molten mass by dissolving them in a minimum quantity of spirit, Finally, sheets are drawn. On an average, life, flow and colour obtained were 36-38 min, 47-49 mm and 11-12·5 units respectively. The wax content (if dewaxed) was found to be 0·12-0·14 percent. This dewaxed lac was used in different shellac formulations to evaluate its performance as compared to the conventional shellac/dewaxed lac. It was observed that water soluble lac and insulating varnish prepared from this lac were comparable. However, in shellac etch primer, it did not work as the product gelled. The process has been passed on to the Production Unit of the Institute.

(A. K. Ghosh, S. K. Saha and A. Pandey)

4.1.5 (i) Effect of drying of seedlac in sun and shade

The drying of seedlac is carried out either in sun or in shade. It is believed that sun drying sometimes darkens the colour of seedlac which is an important price determining factor. A detailed study in this respect was, therefore, undertaken.

It was observed that the darkening of seedlac due to sun drying depended on total time of exposure to the sun. Up to the first one hour exposure to sun, no appreciable change in the colour of seedlac was noticed. But, thereafter, the red colour of the sundried seedlac increased by 0·1 to 0·2 unit for each additional hour of exposure to sun. The darkening effect also depended on the temperature of the sunshine. The change in red colour due to sun drying was maximum when seedlac was dried for 4 hr at 42°-44°C and increased by 13-20 percent. The same sample when dried in sun at 28°-30°C for 4 hr registered an increase in red colour by only 4·55 percent.

The darkening effect depended also on the method and extent of washing of of sticklacs. If properly washed by the conventional method using washing soda or synthetic detergents viz., Genteel, Surf, Gnat, Biz, Det and Key, the red colour of the sun-dried portion was higher by 0·2 to 0·6 unit. But when sticklacs were washed without any washing aid, the darkening was more pronounced and the red colour was higher by 0·5 to 0·8 unit.

The darkening effect depended also on the types of sticklac and was minimum with *kusmi*.

The sticklac, stored under damp conditions resulted in seedlac which developed bluish tinge along with darkening of colour when dried in sun.

Like colour, bleach index of the seedlacs also depended on the time and temperature of sun drying. It remained unchanged for the first one hour of sun

drying but, thereafter, increased on drying. In a typical case (Table 41), bleach index of a seedlac when dried in sun for 4 hr at 42°-44°C increased by 15-17 units, but when the same sample was dried in sun for the same period at 28°-30°C, its bleach index increased by 2-5 units only.

The yellow colour of the seedlac did not show any change during sun drying. Only in a few cases, it was found to increase by one unit. An increase in colour index (1-2 units) was also noticed in most of the cases. Other properties (life and flow) of seedlacs as well as shellac made therefrom did not show any appreciable change.

Thus, the darkening effect on seedlac due to drying in sun depends on the method of washing, duration and temperature of sun drying, and also on type of sticklac. Properly washed seedlac can be dried safely in sun upto a maximum period of one hour. Thereafter, colour and bleach index increase gradually.

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

4.3.1 (iii) Lac-based adhesive (glue) for paper

For preparation of lac-based glue for paper to paper and paper to other surfaces a number of compositions were tried, of which a few are mentioned below:

1.	Seedlac	25·0 parts
	Hydrolysed lac	2·5 ,,
	Borax	7·0 ,,
	Water .	100·0 ,,
2.	Seedlac	25·0 ,,
	Hydrolysed lac	2·5 ,,
	Triethanolamine	4·0 ,,
	Water	70·0 ,,
3.	Seedlac	25·0 ,,
	Hydrolysed lac	2·5 ,,
	Ammonia	5·0 ,,
	Water	95·0 ,,
4.	Seedlac	30·0 ,,
	Hydrolysed lac	3·0 ,,
	Sodium carbonate	3·5 ,,
	Water	100·0 ,,
5.	Seedlac	30·0 ,,
	Sodium Hydroxide	0·3 ,,
	Sodium carbonate	3·0 ,,
	Water	100·0 ,,

Seedlac and hydrolysed lac were added to the alkaline water at 70°-80°C and heating was continued till the solution was complete. The solution was filtered through muslin cloth in hot condition to remove impurities and cooled. A preservative, such as, spirit, formalin, sodium benzoate or copper sulphate was then incorporated.

TABLE 41 — BLEACH INDEX OF SEEDLAC WHEN DRIED IN SUN AND SHADE

Sl No.	*Rangeeni* 1977-78 sticklac washed by 0·1%	Bleach Index when dried in		
		Shade	Sun for 4 hr at	
			42-44°C	28-30°C
1	Genteel	93	108	97
2	Surf	85	101	90
3	Key	95	110	100
4	Gnat	94	111	98
5	Det	93	110	98
6	Biz	96	111	101
7	Washing soda	98	115	100

The performance of the glue prepared above was tested as per IS: 2257-1970 using different qualities of paper on various surfaces mentioned below:

Paper

(a) Writing paper
(b) Type paper
(c) *Kraft* paper
(d) Coated art paper
(e) Cartridge paper
(f) Carlaid paper

Surface

(a) Same surface
(b) Different paper
(c) Glass
(d) G.I. sheet
(e) Wood packing
(f) Muslin cloth
(g) Plastic (polythene)

Storage stability test

The adhesive was stored in different well stoppered glass/plastic containers. It was observed after six months that there was no development of fungus on the surface, sedimentation of the resin or deterioration in adhesive property.

The adhesion of aqueous solution of lac in triethanolamine or sodium carbonate on paper and other surfaces was better than that of ammonical or borax solution. It was found that in case of borax, the paper got coloured. The performance of the aqueous solution of seedlac in sodium carbonate or triethanolamine was found similar and passed the entire test. Since sodium carbonate is cheaper than triethanolamine, it is to be preferred for making the glue. The role of hydrolysed lac is to improve flexibility and adhesion and 10 percent was found optimum. In the composition, hydrolysed lac was replaced by the addition of sodium hydroxide to partially hydrolyse the seedlac (refluxed at 95°C for 3 hr). The performance of this composition was found similar to that of composition-4.

(P. C. Gupta, M. Islam and R. Prasad)

(b) RESEARCHES ON HAND

4.1 Improvement in the Processing Techniques

4.1.5 (ii) (Old No. 4.1.7) Washing of sticklac with detergents

It was reported last year that washing of sticklac with commercial synthetic detergents (0·1% on the weight of sticklac) improved the yield of seedlac by 2 to

8 per cent as compared to conventional process of washing with soda. During the reported period, twelve samples of sticklac have been washed with Biz, Det, Gnat, Key, Surf and Genteel using 0·1, 0·2 and 0·3 percent on the weight of sticklac. It was observed that, unlike washing soda, increase in the amount of detergents did not decrease the percentage yield of seedlac, but improved the colour of seedlac marginally (1-2 units). Investigation carried out at laboratory scale showed a maximum increase in yield of 7·6 percent and decrease in bleach index by 13 units when sticklacs (*rangeeni*) were washed with Genteel and Surf, respectively, as compared to washing soda at the concentration of 0·1 percent (Table 42).

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

4.1.6 (i) Improvements in dewaxing techniques in aqueous medium

It was reported last year that among the filtering aids, performance of cellulose powder was the best. Hence the process was standardized and is given below.

Seedlac (1 kg, 10 mesh, wax content 47·5 g) was dissolved in water (3 l) containing sodium carbonate (80 g) and sodium sulphite (30 g) at 80°-85°C for 45 min. and filtered through muslin cloth to remove the impurities (residue-A, 45 g) which were washed with water (500 ml). Ice (1·5 kg) was added to bring down the temperature to 15-16°C. Then cellulose powder (70 g, 7%) was added, mixed thoroughly and filtered through drill cloth (residue-B, 90 g). Sodium hydrosulphite (20 g, 2% on the weight of seedlac) was also added to the solution in order to get normal colour of lac. The filtrate was diluted to 7 percent lac content with cold water and precipitated with sulphuric acid (5%). The precipitated lac was washed with water to remove acid. Finally, it was boiled in water and converted into sheets. The wax content of the product was found to vary between 0·08 and 0·1 percent.

Further attempts were made to recover the wax from the residue A and residue B by extraction with hot hexane. The wax recovered was found to be 48 per cent (21·6 g from A) and 27 percent (24·3 g from B) respectively, which accounts for total 45·9 g or 95 percent recovery of wax from the seedlac. It was also noticed that fiiltering aid could be reused.

Several charges on a semi-pilot scale, taking 10 kg seedlac per charge, were carried out. The dewaxing was completed within 12 hr. The wax content of the products varied between 0·11 and 0·14 percent.

(A. K. Ghosh)

(ii) Improvements in dewaxing and decolourizing techniques in solvent medium

Dewaxed and decolourized lac is very much in demand. The project was taken up with a view to working out the details and making improvements therein. The filtration of alcoholic solution of seedlac is time consuming. Experiments were carried out to reduce the time of filtration by using various amounts of silver sand filter aid during dewaxing. The best results were obtained when the seedlac and silver sand were mixed in the ratio of 1:2. In a typical case, seedlac (25 g) dissolved in methylated spirit (100 ml, 90%) took 2 hr 45 min to filter at 27°C but when silver sand (50 g) was mixed, the time was reduced to 1 hr 40 min.

For decolourizing, the general practice is to make use of activated carbon. Experiments were initiated to remove the difficulties experienced during filtration of decolourized lac solution. Paper pulp and silver sand were used as filter aids, but proved unsuccessful. Prewashing of the activated charcoal with spirit gave satisfactory results and prevented the creeping of fine charcoal particles with the filtrate.

(R. K. Banerjee)

TABLE 42 — PROPERTIES OF SEEDLACS OBTAINED BY WASHING STICKLACS WITH DIFFERENT WA

Sl No.	Details of sticklac	Properties of seedlacs obtained	Washing aids (%)											
			Washing soda			Biz			Det			Gnat		
			0·1 (Control)	0·2	0·3	0·1	0·2	0·3	0·1	0·2	0·3	0·1	0·2	0·3
1.	*Baisakhi* 1976-77, *palas*, Oct. 1977, Daltonganj	Yield (%)	58·1	56·9	55·9	60·6	60·6	60·5	60·7	60·6	60·7	61·2	61·2	61·3
		Colour index	23·0	22·0	22·0	23·0	23·0	22·2	23·0	23·0	23·0	22·0	22·0	22·0
		Bleach index	120·0	119·0	118·0	118·0	116·0	116·0	117·0	117·0	116·0	115·0	115·0	114·0
2.	*Baisakhi* 1977-78, *palas*, October 1978, Namkum	Yield (%)	60·2	59·0	58·1	63·3	63·3	63·4	63·5	63·4	63·5	63·3	63·2	63·2
		Colour index	17·0	16·0	15·0	17·0	16·0	16·0	17·0	16·5	16·5	16·0	16·5	16·0
		Bleach index	98·0	97·0	95·0	96·0	96·0	95·0	93·0	93·0	93·0	94·0	94·0	93·0
3.	*Baisakhi* 1977-78, *ber*, October 1978, Namkum	Yield (%)	62·7	61·8	61·8	65·2	65·2	65·1	65·2	65·3	65·3	65·5	65·5	65·4
		Colour index	18·0	17·0	16·0	18·0	17·5	17·5	18·0	18·0	17·5	17·5	17·5	17·0
		Bleach index	102·0	100·0	99·0	100·0	100·0	98·0	100·0	99·0	99·0	99·0	98·0	98·0
4.	*Baisakhi* 1977-78, *palas*, April 1978, Daltonganj	Yield (%)	63·2	61·9	59·8	65·4	65·4	65·3	65·8	65·7	65·8	65·7	65·8	65·6
		Colour index	22·0	21·0	19·0	22·0	21·5	21·0	22·0	22·0	21·5	20·5	20·5	20·0
		Bleach index	112·0	110·0	108·0	110·0	110·0	108·0	110·0	108·0	108·0	108·0	108·0	106·0
5.	*Katki* 1978, *ber*, October 1978, Daltonganj	Yield (%)	58·2	57·3	55·9	60·1	60·3	60·1	61·2	61·1	61·1	61·8	61·7	61·7
		Colour index	22·0	21·0	20·0	22·0	22·0	22·0	22·0	22·0	22·0	21·5	21·5	21·5
		Bleach index	116·0	115·0	113·0	114·0	114·0	113·0	114·0	114·0	113·0	113·0	113·0	112·0
6.	*Baisakhi* 1978-79, *ber*, October 1979, Balarampur	Yield (%)	63·7	62·7	61·5	66·3	66·2	66·2	66·8	66·8	66·8	68·1	68·1	68·1
		Colour index	18·0	17·0	16·0	18·0	18·0	18·0	18·0	18·0	17·0	17·0	17·0	17·0
		Bleach index	97·0	97·0	96·0	92·0	92·0	92·0	94·0	94·0	94·0	95·0	95·0	95·0
7.	*Aghani* 1976-77, *kusum*, January 1977, Namkum	Yield (%)	68·0	66·8	65·7	69·7	69·7	69·7	70·3	70·2	70·2	70·5	70·5	70·4
		Colour index	14·0	14·0	13·0	14·0	14·0	14·0	14·0	14·0	14·0	14·0	14·0	13·0
		Bleach index	91·0	91·0	90·0	89·0	89·0	89·0	89·0	89·0	89·0	88·0	88·0	87·0
8.	*Jethwi* 1977, *kusum*, October 1977, Namkum	Yield (%)	69·1	67·8	66·5	70·0	70·0	70·0	70·5	70·4	70·5	71·3	71·3	71·3
		Colour index	14·0	14·0	13·0	14·0	14·0	14·0	14·0	14·0	14·0	14·0	14·0	13·0
		Bleach index	90·0	90·0	89·0	88·0	88·0	88·0	88·0	87·0	87·0	88·0	86·0	86·0
9.	*Aghani* 1977-78, *kusum*, January 1978, Daltonganj	Yield (%)	68·8	67·5	66·1	71·3	71·2	71·2	71·6	71·5	71·5	73·1	73·1	73·1
		Colour index	14·0	14·0	12·0	14·0	14·0	14·0	14·0	14·0	14·0	14·0	13·0	13·0
		Bleach index	93·0	91·0	90·0	88·0	88·0	88·0	88·0	88·0	88·0	86·0	86·0	86·0
10.	*Jethwi* 1978, *kusum*, October 1978, Daltonganj	Yield (%)	69·6	68·8	67·4	72·3	72·3	72·2	72·2	72·1	72·1	74·2	74·2	74·1
		Colour index	13·0	13·0	12·0	13·0	13·0	13·0	13·0	13·0	13·0	13·0	12·0	12·0
		Bleach index	90·0	89·0	89·0	85·0	85·0	84·0	85·0	85·0	85·0	85·0	84·0	84·0
11.	*Aghani* 1978-79, *kusum*, January 1979, Namkum	Yield (%)	70·1	68·6	67·2	73·8	73·8	73·8	73·4	73·4	73·4	75·5	75·4	75·4
		Colour index	12·0	11·0	10·0	12·0	12·0	12·0	12·0	12·0	12·0	12·0	11·0	10·0
		Bleach index	86·0	85·0	84·0	83·0	83·0	83·0	84·0	84·0	84·0	83·0	83·0	83·0
12.	*Jethwi* 1979, *kusum*, October 1979, Namkum	Yield (%)	71·5	70·0	68·8	74·6	74·6	74·5	76·1	76·0	76·0	76·7	76·7	76·6
		Colour index	10·0	9·0	8·5	10·0	10·0	10·0	10·0	10·0	10·0	10·0	10·0	9·0
		Bleach index	85·0	84·0	83·0	84·0	84·0	83·0	840	84·0	83·0	84·0	84·0	84·0

Key			Surf			Genteel		
0·1	0·2	0·3	0·1	0·2	0·3	0·1	0·2	0·3
62·1	62·1	62·1	62·8	62 7	62·7	64·3	64·2	64·2
22·0	21·0	22·0	21·0	21·0	21·0	21·0	21·0	21·0
116·0	116·0	115·0	110·0	109·0	109·0	112·0	112·0	112·0
64·1	64·1	64·1	65·4	65·5	65·4	67·5	67·5	67·5
16·5	16·0	16·0	10·0	15·0	15·0	16·0	15·0	15·0
95·0	94·0	95·0	85·0	85·0	85·0	93·0	93·0	93·0
66·1	66·0	66·1	68·2	68·2	68·1	70·1	70·1	70·2
17·0	17·5	16·5	17·0	16·0	16·0	16·0	16·0	16·0
98·0	99·0	98·0	90·0	90·0	90·0	94·0	93·0	94·0
66·7	66·5	66·5	68·7	68·6	68·7	70·3	70·3	70·3
21·5	20·5	20·5	21·0	21·0	20·0	20·0	20·0	20·0
107·0	106·0	105·0	100·0	100·0	100·0	102·0	102·0	101·0
62·1	62·2	62·1	65·5	63·6	63·5	65·2	65·3	65·3
21·0	21·0	21·0	21·0	21·5	20·5	20·5	20·5	20·5
113·0	112·0	111·0	106·0	106·0	105·0	108·0	108·0	108·0
67·4	67·3	67·3	69·1	69·1	69·1	71·3	71·3	71·2
17·0	17·0	16·0	17·0	17·0	16·0	17·0	17·0	16·0
92·0	92·0	91·0	84·0	84·0	84·0	91·0	91·0	91·0
70·4	70·4	70·4	72·1	72·1	72·1	73·3	73·3	73·3
14·0	14·0	13·0	14·0	13·0	13·0	14·0	13·0	13·0
90·0	89·0	88·0	86·0	85·0	84·0	86·0	86·0	86·0
71·5	71·5	71·5	73·3	73·3	73·3	76·6	74·6	76·6
14·0	14·0	13·0	14·0	13·0	13·0	14·0	13·0	13·0
88·0	86·0	85·0	85·0	84·0	83·0	86·0	85·0	85·0
73·2	73·1	73·1	73·8	73·8	73·8	74·5	74·5	74·5
13·0	13·0	13·0	13·0	13·0	13·0	13·0	12·0	12·0
85·0	85·0	85·0	82·0	82·0	81·0	84·0	84·0	84·0
73·8	73·7	73·7	74·8	74·8	74·8	75·1	75·0	75·0
12·0	12·0	12·0	12·0	12·0	12·0	12·0	11·0	11·0
84·0	85·0	85·0	82·0	81·0	81·0	84·0	83·0	83·0
75·6	75·6	75·6	76·1	76·1	76·0	77·5	77·5	77·4
11·0	10·0	10·0	11·0	11·0	10·0	10·0	10·0	10·0
83·0	83·0	83·0	80·0	80·0	80·0	82·0	82·0	82·0
76·8	76·8	76·8	77·3	77·3	77·3	79·0	79·0	79·0
10·0	10·0	10·0	9·0	9·0	9·0	9·0	9·0	9·0
84·0	84·0	84·0	80·0	80·0	80·0	83·0	83·0	83·0

4.2 Rubber-Shellac Combinations

4.2.1 Incorporation of modified lacs into rubber

Last year, the effect of the incorporation of shellac and zinc salt of lac into a blend of natural rubber (NR) and styrene-butadiene rubber (SBR) using easy processing channel (EPC) and high abrasion furnace (HAF) black fillers was studied. The mechanical properties, such as, tensile strength, tear resistance, modulus, etc. were determined. During the reported period, abrasion resistance of the same compositions was studied. It may be seen from the data (Table 43) that with both the fillers, abrasion resistance decreases by the incorporation of shellac. The lowering is more pronounced with HAF than EPC.

TABLE 43 — EFFECT OF INCORPORATION OF SHELLAC AND ZINC SALT OF LAC ON THE PROPERTIES OF RUBBER BLEND

(Base: Mix.$_1$ × NR, 50; SBR, 50; ZnO, 4; PBN, 1; stearic acid, 1; accelerator, 1; and sulphur, 2)

Shellac added per 100 parts of blend	Abrasion resistance index
FILLER EPC (70 PARTS/100 PARTS BLEND)	
0	100·00
5	93·30
10	65·10
15	65·90
20	65·20
FILLER HAF (40 PARTS/100 PARTS BLEND)	
0	100·00
5	45·70
10	45·50
15	30·50
20	28·10

Zn, salt of lac added per 100 parts of blend	Abrasion resistance index	Flexing (no. of revolutions after which cracking started) (in lakhs)
	FILLER EPC (70 PARTS/100 PARTS BLEND)	
0	100·00	0·80
5	81·50	1·00
10	50·00	0·60
15	Not up to mark	0·60
20	do	0·60
	FILLER HAF (40 PARTS/100 PARTS BLEND)	
0	100·00	1·00
5	130·00	1·20
10	50·40	0·80
15	20·00	0·60
20	15·80	0·60

In case of Zn-salt of lac also, abrasion resistance decreases with both the fillers, except that it improves with 5 parts of Zn-salt of lac with HAF filler. The flexing improved with 5 parts of Zn-salt of lac in presence of both the fillers.

(R. Singh and B. B. Khanna)

4.3 Use of Lac in Adhesives

4.3.1 (ii) Modified lacs (with synthetic monomers) as addhesives

A composition based on dewaxed decolourized lac (60 parts) modified with ethyl/methyl acrylate (40 parts) was found suitable last year for fixing sun mica to wood surface. During the period under report bleached lac has been modified with the same monomers.

Aqueous ammonical bleached lac solution was reacted with the monomers in presence of potassium permanganate as initiator in inert atmosphere, at room temperature for 4 hr. The adhesive property of the product over wooden surfaces was not found satisfactory. When instead of ammonia, triethanolamine was used (*p*H 8·3 to 8·5), the adhesion was found encouraging. It further increased on the addition of hydrolysed lac (10% on the weight of bleached lac).

Several compositions varying the concentration of monomer and bleached lac were prepared. Optimum composition was found to be ethyl/methyl acrylate bleached lac 40:60 or 50:50 (Table 44).

The resulting emulsion was used for fixing sun mica over wooden surfaces. The adhesion between the two surfaces was fairly good and the sun mica could not be pulled out by a knife after ageing for five days at room temperature.

(P. C. Gupta, M. Islam and R. Prasad)

4.3.2 Heat and water proof decorative laminates

Last year, the top layers of decorative laminates were coated with shellac melamine resin/shellac modified with isocyanates but the desired surface resistance could not be achieved. During the period under report, the top layers were coated

TABLE 44 — ADHESIVE STRENGTH OF BLEACHED LAC MODIFIED WITH MONOMERS (ON WOODEN SURFACE)

Sl No.	Monomer bleached lac (g)	Hydrolysed lac (g)	Bond strength with (ton/sq. inch)	
			Ethyl acrylate	Methyl acrylate
1	0:100	Nil	0·04	0·04
2	0:100	10·00	Does not dry	Does not dry
3	25:75	7·5	0·12	0·14
4	33:67	6·7	0·20	0·22
5	40:60	Nil	0·15	0·11
6	40:60	6·0	0·25	0·24
7	50:50	5·0	0·25	0·24
8	60:40	4·0	0·25	Gelled
9	70:30	3·0	Gelled	Gelled

by varying the concentration and increasing the number of coatings of shellac butylated melamine resin and also using shellac acrylate combinations. The boards, thus obtained, were tested with iodine, caustic soda and silver nitrate solutions as per IS:2046-69 but none of the compositions passed the tests. Subsequently, butylated melamine resin alone, with and without catalyst, was tried as a top coat but it was also unsuccessful. However, when urea resin with and without catalyst was used for top coats, the boards made therefrom passed all the above tests except the silver nitrate test in which case the resulting spot could be washed away with water but light faint colour reappeared after some time.

(P. C. Gupta and M. Islam)

4.3.3 Lac as an adhesive for utilization of waste mica

It was reported earlier (A.R.: 1974-76, p. 109) that insulating sheets/boards prepared by using calcined mica with butylated melamine resin modified lac and hydrolysed lac gave BDS 17·5-23·5 kV/mil. The sheets, thus prepared, were of 15×15 cm size. During the reported period bigger sheets (30×30 cm) using the same composition were prepared in a hydraulic press. The breakdown strength was found to be somewhat low (10-12·5 kV/mil) and the sheets could resist water up to 24 hr without delamination. A few sheets of calcined mica with lac-urea-hydrolysed lac composition were also prepared, but the same were not satisfactory.

(P. C. Gupta and R. Singh)

4.3.4 Modified hydrolysed lac (with epoxy resin and isocyanates) as adhesives

Preliminary experiments were carried out to introduce epoxy groups by the interaction of *total* hydrolysed lac and epichlorohydrin using different molecular ratios (1:1, 1:2, 1:4, 1:6) in aqueous alkaline medium. Examination of the end products showed that only one epoxy group could be introduced.

(R. K. Banerjee and P. C. Gupta)

(c) RESEARCHES CONTEMPLATED

(i) Making of shellac from *kiri* without use of alcohol.

(ii) Standardization and pilot plant studies on shellac based water thinnable *red oxide* primers.

E. EXTENSION DIVISION

(a) RESEARCHES COMPLETED

Nil

(b) RESEARCHES ON HAND

3.3.4.1 Studies on AC deposition of shellac based paints

Lac in aqueous medium using ammonia/triethanolamine as the solubilizing base was tried initially for depositing films but no success could be achieved. Next, aqueous lac solution (20% w/v) containing triethanolamine was prepared. To this lac solution, chlorinated rubber solution (20%) in chloroform was added and mixed thoroughly by stirring. The resultant product was taken in a glass jar and

regulated alternating current was passed through two mild steel plates dipped in the jar. The deposition of films on the plates was found to be completed within five min. The plates were then taken out, washed and baked at 100°C for 20 min. Thus, films were deposited by changing shellac-rubber ratios 2:1, 4:1 and 6:1. The thickness of the baked films was found to vary from 0·3-0·4 mil. It was observed during deposition that with the decrease in shellac proportion in the composition, more and more heat was evolved and below the ratio of 4:1 (shellac: rubber), the deposition of films became difficult. The deposited films were uniform and smooth. A few deposited panels when kept in salt solution (2%) for five days showed no rusting or blistering.

A few more compositions having ratios 8:1, 10:1 and 12:1 (shellac: rubber) were prepared and the deposition was tried. In every case uniform coating of thickness 0·3-0·4 mil was obtained. The deposition was also carried out with two of the above compositions (6:1 and 8:1) pigmented with titanium dioxide keeping the pigment/binder ratio 2:1, It was noticed that more pigment was deposited on the outer surface than the inner surface of the panels. Thickness of the baked films was found to be 0·5-0·8 mil and 0·3-0·5 mil respectively.

(A. Pandey and S. K. Saha)

5.2 Development of Shellac Bond Powder

It was reported last year that 20 kg of the shellac bond powder prepared according to the method developed earlier was sent to M/s Bharat Heavy Electricals Ltd., Bhopal for evaluation and large scale trials. The evaluation, however, could not be carried out as the material was reported lost during transit. In the meanwhile, the method of preparation of the bond powder was further standardized and the optimum conditions at different stages of preparation were found out. The yield of the bond powder was found to be about 70 percent on the weight of the seedlac. Pilot plant trials for the manufacture of the bond powder were also carried out and the process was successfully examined for the manufacture of the product on a plant having a capacity of 20 kg/batch. Another lot (20 kg) of the powder was prepared and sent to M/s Bharat Heavy Electricals Ltd., Bhopal for evaluation. Preliminary report indicated that the performance of the product was satisfactory and the heat polymerization time was also within the specified limit. Final report is awaited.

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

5.3 Effect of Storage on Sticklac

The studies on the effect of storage on sticklac were undertaken with *baisakhi* 1977-78 *ari* sticklac collected from Ranchi and Palamau districts and another lot of *baisakhi* 1978-79 *ari* sticklac collected from Purulia district. The sticklac samples were subjected to moisture test at weekly intervals. The samples were kept stored in gunny bags under room conditions and checked for blocking, if any, at regular intervals. It has been found that blocking of sticklac stops when the moisture content comes down to 5·5 percent or below. It took about 3-4 months to reach this stage under normal practice of drying. The sticklac samples were converted to seed lac at intervals of 6 months and tested for flow, life, impurities (hot alcohol insolubles), colour, and rate of filtration. The results are given in Table 45. Two more samples, one *aghani* 1979-80 (Ranchi) and another *baisakhi* 1979-80 *ari* (Palamau), were collected during 1980 and kept stored in gunny bags after the moisture content of the sticklacs came down to approximately 5 percent.

(S. K. Saha and A. K. Ghosh)

TABLE 45 — EFFECT OF STORAGE ON STICKLAC

Sample no.	Type of sticklac	Place of storage	Period of storage (months)	Properties of seedlac obtained from the stored sticklac				
				Impurities (%)	Colour	Flow (mm)	Life under heat (min)	Rate of filtration at 25°C (ml)
1	*Baisakhi* 1977-78 *ari* (Plamau)	Namkum	Nil	3·20	12	40	55	65
			6	3·10	12	38	53	54
			12	3·70	11	30	53	57
			18	3·65	12	20	51	58
			26	3·62	13	20	49	60
2	*Baisakhi* 1977-78 *ari* (Plamau)	Kundri	Nil	3·20	12	40	55	65
			8	4·00	12	10	42	57
			21	4·75	12	8	40	45
			26	4·75	13	8	37	36
3	*Baisakhi* 1977-78 *ari* (Ranchi)	Namkum	Nil	3·60	11	44	52	63
			7	3·60	11	25	50	60
			14	4·10	14	25	45	58
			20	5·24	15	23	46	52
4	*Baisakhi* 1978-79 *ari* (Purulia)	Namkum	Nil	4·05	12	44	60	69
			7	5·00	12	40	58	64
			14	4·35	14	39	54	67
5	*Baisakhi* 1979-80 *ari* (Palamau)	Namkum	Nil	5·8	15	43	56	63
6	*Aghani* 1979-80 (Ranchi)	Namkum	Nil	2·9	12	51	57	59

(c) SPONSORED RESEARCH

Commercial Feasibility Studies on Storage of Sticklac and Seedlac

Sticklac Storage Experiments

The study on storage of sticklac and seedlac sponsored by the Ministry of Commerce, Govt. of India (State Trading Corporation of India) was taken up from March, 1979 initially with three samples of *katki* 1978 sticklac 20 (tonnes) purchased from Palamau, Manbhum and Singhbhum areas. Subsequently, three samples of *baisakhi* 1978-79 *ari* sticklac from West Bengal, Madhya Pradesh and Bihar and two samples of *baisakhi* 1979-80 *ari* sticklac from Manbhum and Palamau areas (total 15 tonnes) were also purchased. These were stored on cemented floor in layers of 30, 60 and 90 cm heights and also in gunny bags (in stacks of five). In two cases, the samples of sticklac were also stored in plastic bags.

Samples of sticklac drawn from each lot at intervals of 6 months were converted into seedlac and tested for impurities (hot alcohol insolubles), colour, flow, life, and rate of filtration. The seedlacs obtained initially from sticklac were also

subjected to above tests at intervals of three months but those obtained from subsequent conversions were tested only once immediately after washing.

The observations based on the data recorded during the period under report are as follows:

(i) *Moisture content and blocking behaviour*

The *katki* sticklacs were received in almost dry condition (moisture content 4·5% or below). No serious tendency of blocking was observed furing the period of storage. The moisture content increased by 0·5-1·5 per cent during August-September (rainy season). Loose lump formation of various degrees was noticed in the lots kept in gunny bags and it was more pronounced in the bags kept in contact with the floor (sticklacs also showed higher moisture content). The mosture content however, came down to 4 and 4-6 percent during October after which there was no lump formation.

The *baisakhi* sticklacs (procured from Jhalda and Balarampur, Madhya Pradesh, and Khunti and Bundu areas) which had moisture contents between 6·5% and 8% on arrival, started blocking after 12 days of storage on cemented floor and also in gunny bags. Blocking, however, stopped when the moisture content reached 4·5 per cent or below. It took about 4 months to reach this stage under normal practice of drying.

(ii) *Yield and initial flow*

The values for yield and initial flow of seedlacs obtained from sticklacs collected from different areas are given below:

Sl No.	Sticklac		Yield of seedlac (%)	Initial flow (mm)
1. *Katki*	1978	(Palamau)	27·2	27
2. *Katki*	1978	(Manbhum)	45·6	38
3. *Katki*	1978	(Singhbhum)	45·0	32
4. *Baisakhi*	1978-79	(Purulia)	54·4	50
5. *Baisakhi*	1978-79	(M.P.)	41·3	43
6. *Baisakhi*	1978-79	(Manbhum)	53·4	48
7. *Baisakhi*	1979-80	(Manbhum)	60·0	50
8. *Baisakhi*	1979-80	(Palamau)	41·0	43

(iii) *Flow*

The flow value was found to be profoundly affected by storage. In almost all cases, it started decreasing from the start and dropped by 8-17 units during the first 6-7 months while in some cases decrease was more than 30 units after 18 months of storage. It was also noticed that deterioration in respect of flow was maximum in the case of sticklacs kept at 90 cm height on the floor and minimum when sticklacs were kept in gunny/plastic bags. Thus, with *katki* sticklacs, the flow values were between 15 and 20 mm when stored in gunny bags for 18 months, while the value were nil for other conditions of storage for the same period.

Similarly, in case of *baisakhi* 1978-79 sticklac (Purulia), the flow value decreased by only 10 units after 18 months of storage in gunny bags, while in other conditions of storage a decrease of 25-30 units was observed.

(iv) *Hot alcohol-insolubes*

There was no significant increase in hot alcohol insolubles of the seedlacs obtained from sticklacs stored in gunny bags for first 18 months. However, a marked rise in the insolubles was observed in the case of samples stored on floor particularly at 90 cm height.

(v) *Colour index*

As regards colour index, the increase in value was not progressive although in most cases the colour index was minimum in case of sticklacs stored in gunny bags.

(vi) *Rate of filtration*

The rate of filtration decreased with the period of storage, the decrease being slow during first 12 months and rapid thereafter.

(vii) *Life*

In case of life under heat, the value, in general, diminished by 8-12 units during 18 months' storage. The position was however better for the first 12 months where the change was only by 3-5 units.

No significant difference was observed between gunny and plastic bag storage as far as quality deterioration is concerned. A definite advantage is, therefore, indicated in storing sticklac in gunny/plastic bags with a moisture content 5 per cent or below as the quality can be maintained longer and better

Seedlac storage experiments

Twelve quintals of Manbhum *baisakhi* 1979 seedlac (initial flow value 49 mm) were received from BISCOLAMF in July, 1979. Six quintals of the seedlac were stored in ordinary godown at Ranchi in double gunny bags (12 bags of 50 kg each) and the balance quantity (8 bags of 75 kg each) in A.C. godown at Calcutta.

The seedlacs were checked periodically for flow, life etc. Practically no change in the flow value was observed during the first 6 months. Flow value, however, dropped by 5 and 14 units after 18 months' storage in A.C. and ordinary godowns, respectively.

Another sample of Manbhum *baisakhi* 1980 seedlac having initial flow value 64 mm which has been kept stored in A.C. gowown at Calcutta and in ordinary godowns at Calcutta and Ranchi, is being examined for its properties periodically to ascertain the effect of different storage conditions.

(S, K. Saha)

(d) RESEARCHES CONTEMPLATED

Studies on the problems of hand made shellac manufacturing units and their possible remedies in Purulia district.

3. EXTENSION

The principal extension activities carried out by the Extension Division were as follows:

(1) Large scale cultivation of lac at Kundri
(2) Technical service and development work
(3) Publicity
(4) Testing of lac and lac products
(5) Training
(6) Production and sale of special shellacs in the production unit

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

Technical guidance was continued to be rendered to the Forest Department, Bihar in running their lac farm at Kundri (Daltonganj), consisting, of about 40,000 *palas* trees, The year-wise information with regard to the number of trees utilised, amount of broodlac used, yield of lac sold, expenditure incurred, and net profit, is given below:

Years	No. of trees	Brood lac used (kg)	Yield (kg)		Lac sold (kg)		Revenue received (Rs)	Ex-penditure (Rs)	Net profit (Rs)
			Brood lac	Stick lac	Brood lac @ Rs 6/ per kg	Stick lac @ Rs 3/ per kg			
1979	37,712	8238	8688	5828·7	450	5828	20184.00	14311.25	5872.75
1980	34,517	6696	7081	4236·0	385	4236	15018.00	9428.25	5589.75

(2) *Technical service and development work*

The Division continued to maintain close touch with various development agencies interested in lac. The Director and the Senior Scientist attended several meetings of the Task Force on lac constituted by the State Planning Board, Govt. of Bihar. The Scientist also visited some important industries and held discussions regarding the ways and means to increase the consumption of lac in those industries.

Some of the important activities are listed below:

(i) Contacts were established with a leading paint manufacturer and a leading rubber manufacturer. A sample of shellac etch primer was supplied to the former for evaluation. The sample was found satisfactory in all respects except that it showed lifting tendency when nitrocellulose or alkyd/amino stoving finish was coated over it.

(ii) A request was received from India Security Press, Nasik for developing an improved lacquer to be used on aluminium plates for wet offset printing. After several trials, a shellac based lacquer of the following composition was supplied:

Dewaxed orange shellac	25 g
Hydrolysed lac	2 g
Sprit	100 ml
Butanol	10 ml
Phosphoric acid	1 g
Pigment	1·5 g

The lacquer was reported to have a satisfactory viscosity (15 sec at 32°C) and specific gravity (0·88). The drying time, however, was somewhat faster than required.

(iii) Technical notes and schemes for the manufacture of sealing wax, bleached lac, gasket shellac compound, Melfolac, etc. were supplied to several parties on request. Technical information about lac coated urea was also supplied to several organisations.

(iv) Samples of shellac and lac dye were sent to several organizations for their research work.

(v) At the request of the Lac Development officer, Bihar, a scheme for establishing Lac Coated Earthenware Units was prepared and supplied.

(vi) Schemes for establishing wax Extraction Plant, Lac Coated Urea Plant and Shellac Manufacturing Unit sent by two financial organisations were scrutinized and the feasibility reports were given.

(vii) Literature on various paints and varnishes developed by the Institute were sent to the Secretary, Indian Paint Association, Calcutta.

(viii) A commercial firm in Delhi was supplied with information regarding the technical preparation of Aleuritic acid, and it is reported to have taken up manufacture of the product.

(ix) A total of 46 crop samples received from various lac farms were examined for forecasting the date of larval emergence and ascertaining the cause of insect mortality.

(x) Efforts were made to establish contacts with different Agro-Service Centres in lac growing States. A handout was prepared and distributed to these Centres. Literature on lac culture was also supplied to several parties.

(3) *Publicity*

The Institute participated in the exhibition at Calcutta from 13-15 January, 1979 organized by the Indian Paint Association on the occasion of the Ninth All India Paint Conference and in the exhibition-cum-get together of National Laboratories with small and medium entrepreneurs organized by the State level R and D Committe, West Bengal at the premises of Birla Industrial and Technological Museum, Calcutta from 8-11 April, 1979, The Institute also participated in the Agricultural and Industrial exhibition organized in Feb. 1979 by the State Bank of India at Satbarwa, in the Rural Development Exhibition organized by the Associated Cement Company, at Jhinkpani from 30th May to 2nd June,

1979, in the Kisan Mela organized by D.V.C. (Soil Conservation) at Hazaribagh during 20-21st March, 1980 and in the Rabi and Kharif Kisan Melas organized by Ranchi Agricultural College, Kanke during 1979 and 1980. Besides these, exhibits were also sent for display at the exhibition organized in the premises of I.A.R.I., New Delhi during the Golden Jubilee Celebrations of I.C.A.R. Exhibits and literature were supplied to the Principal, M.G.M. Primary School, Killa Pavdi, Bulsar (Gujarat) and the Museum Curator, Department of Botany/ Zoology, Desbandhu College, New Delhi, for display in their museums.

(4) *Testing of lac and lac products*

During the period, test reports for 536 samples of seedlac, shellac and sealing wax, comprising 1726 tests, were issued from the division.

(5) *Training*

(a) *Improved Methods of Lac Cultivation (Regular Course)*

Four regular certificate courses of six-month duration were conducted during the period under report and in all 20 trainees, including 8 sponsored by the Department of Agriculture, Government of Uttar Pradesh, completed their training successfully. Another batch of 6 candidates was also admitted for the session starting from October, 1980 and their training is in progress.

(b) *Short Term Courses*

Three short term courses on "Lac Cultivation Practices" were arranged during the period for 8 in-service trainees deputed by the Directorate of Lac Development, Ranchi and the Gujarat Forest Development Corporation, Vadodara.

(6) *Production Unit*

The Unit continued the production of different grades of special shellacs, as given below, for sale to the interested parties.

Sl No.	Materials	Quantity (kg)	Price (Rs)
1.	DXO-grade water soluble lac	236·25	7087.50
2.	DXG-grade water soluble lac	190·00	3914.00
3.	ASK-grade Autoclave shellac	25·00	212.50
4.	BHL-grade hydrolysed lac	5·00	146.50
5.	BOL-grade hydrolysed lac	0·50	9.50
		456·75	11370.00

4. PAPERS PUBLISHED

(a) Publications

The Institute publishes its research findings in leading Scientific and Technical Journals. In addition, a few books and one monograph have also been published. The total number of publications as on 31st December 1980 is given below:

1. Bulletins	
(i) Chemical	154
(ii) Entomological	93
2. Technical notes	30
3. Research notes	
(i) Chemical	85
(ii) Entomological	52
4. Miscellaneous technical publications	
(i) Physico-chemical	25
(ii) Entomological	48
5. Books and Monographs	14
6. Pamphlets and leaflets	24

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

List of papers published during the years 1979 & 80

Sl No.	Authors	Title of paper	Name of Journal
		A. ENTOMOLOGY DIVISION	
1.	Malhotra, C. P. and Katiyar, R. N.	Chemical control of the lac predator, *Eublemma amabilis*, moore II. Relative toxicity of insecticides (safer to lac insect) against the caterpillars of *Eublemma amabilis*	*Indian J. Ent.*, 1979, **41**(2), 187-189
2.	Mehra, B. P. Naqvi, A. H. and Sah, B. N.	Note on the emergence of dimorphic males of lac insect	*Ind. J. agri. Sci.*, 1979, **49**(1), 57-60
3.	Srivastava, D. C. and Mehra, B. P.	Studies on the abundance of various insects associated with the Indian Lac insect, *Kerria lacca* (Kerr.)	*Ind. J. Ecol.*, 1980, **7**(1), 96-104
4.	Srivastava, D. C. and Sinha, T. B.	*p*H in the gut of *Liposcelis entomophillis* (End.) (Psocoptera, liposcelidae)	*Beitr. Zool.*, 1980, **26**(3), 341-343

5.	Ibid	Passage of food through the gut of *liposcelis entomophillis* (End.) (psocoptera, Liposcelidae)	*Beitr. Zool.*, 1980, **26**(3), 345-347
6.	Srivastava, D. C. and Tripathi, R. L.	Prospects of apiculture in tribal areas of Chotanagpur	*Proc. Second International conference on apiculture* (abstract) *in tropical climate* I.A.R.I., New Delhi, 1980, 23

B. AGRONOMY AND PLANT GENETICS DIVISION

1.	Sinha, S. S. N. and Kumar, P.	Meiotic analysis in thirteen varieties of *Cajanus cajan* (L) Mill sp.	*Cytologia*, 1979, **44**, 571-580
2.	Ibid	A case of colchiploidy in *Moghania macrophylla* (wild) O. Ktze	*J. Cytol. Genet.*, 1979, **14**, 150-152
3.	Purkayastha, B. K.	Effect of gibberellic acid on the growth of lac hosts	*Ind. J. agri. Sci.*, 1979, **49**(8), 620

C. CHEMISTRY DIVISION

1.	Rahman, A., Bhattacharya, P. R. and Khanna, B. B.	Cation exchange resin from shellac	*Res. and Ind.*, 1979, **24**, 235
2.	Khanna, B. B.	Lac production, utilisation and future	*Proc. Symp. Production and Utilisation of Forest* products R. R. L., Jammu, Vol. I & II, 1979, 135-41
3.	Khanna, B. B. and Tripathi, S. K. M.	Modification of lac	*Chemicals and Petrochemicals J.*, **10**, 1979
4.	Sengupta, S. C., Agarwal, S. C. and Prasad, N.	Quantitative estimation of aldehydic acids in lac resin and its fractions	*J. Oil Col. Chem. Assoc.*, **62**, 1979, 85-88
5.	Srivastava, B. C. and Kumar, Shravan	Agricultural uses of lac	*Agr. Agro Ind. J.*, 1979, **12**(4), 24-26
6.	Srivastava, B. C.	Pharmaceutical potentialities of lac	*Ind. J. Pharm. Ed.*, 1979, **13**(3), 1-4
7.	Goswami, D. N.	The dielectric behaviour of natural resin, shellac	*J. App. Poly. Sci.*, 1979, **23**, 529-37
8.	Ibid	Dielectric behaviour of the constituents of the natural resin, shellac	*J. Appl. Poly. Sci.*, 1979, **24**, 77-84
9.	Ibid	The relationship between glass transition and melting temperatures of natural resin	*J. Oil Col. Chem. Assoc.*, **63**, 1980, 101-2
10.	Tripathi, S. K. M. and Khanna, B. B.	Modification of hydrolysed lac with epichlorohydrin and epoxy resin	*J. Oil. Col. Chem. Assoc.*, **63**, 1980, 149-52

D. TECHNOLOGY DIVISION

1.	Banerjee, R. K. and Sengupta, S. C.	Modification to total hydrolysed lac — Part I Preparation of rebulac	*Paint India*, 1979, **29**(1), 22-28
2.	Prasad, K. K. and Gupta, P. C.	Cold setting sealing wax in paste form	*Res. and Ind.*, 1980, **25**(1), 146-48
3.	Ghosh, A. K. and Sengupta, S. C.	Improvement in lac processing techniques Part II Production of lac wax of superior quality	*Res. and Ind.*, 1979, **24**, 232-34

E. EXTENSION DIVISION

1.	Sengupta, S. C., Ghosh, D., Das, R. and Sinha, A.	Modification of shellac: Part I using ethylene glycol and dicarboxylic acids	*J. Oil. Col. Chem. Assoc.*, **63**, 1980, 15-22

5. CONFERENCES AND SYMPOSIA

The Institute has been deputing Scientists in conferences/symposia and training held in various institutions/organisations/universities of India. The details for the period under report are as follows:

1. Dr S. C. Agarwal S-2, 5-7 March, 1979	Symposium on ' Production and Utilisation of Forest Products ' held at R.R.L., Jammu.
2. Sri S. C. Srivastava, S-1 4 June to 2 July, 1979	Summer Institute on ' Breeding for disease resistance and nutritional quality ' held at Punjab Agricultural University, Ludhiana.
3. Sri S. G. Choudhary S-1, 4-30 June, 1979	All India Summer Institute in teaching of Insect Pathology related to biological control of pests and diseases, held at University of Agricultural Sciences, Bangalore.
4. Sri Radha Singh S-1, 29-31 January, 1980	International Conference on ' Structure property relation of rubber' at I.I.T., Kharagpur.
5. Dr D. C. Srivastava S-1, 29 Feb.-4 March, 1980	Second International Conference on Apiculture in tropical climate held at I.A.R.I., New Delhi.

6. SUMMARY

A. ENTOMOLOGY DIVISION

(a) RESEARCHES COMPLETED

1.1.2 None of the cultivation practices tried for utilising *bhalia* for raising the *jethwi* crop has shown any promise.

1.1.3 *Rangeeni* lac cultivation has been tried using *ber* and *galwang* bushes in alternation, the former for raising the *katki* crop and the latter for the *baisakhi*. It has been found that the brood lac produced on one does not perform well for raising the following crop on the other suggesting that this alternation of hosts is not suitable for *rangeeni* lac cultivation.

1.1.5 Seven plant species were tried as alternative *rangeeni/kusmi* hosts. Of these, *putri* has shown promise for raising the summer crops particularly the *baisakhi* and *baryari* for the *aghani*.

1.3.2 The study on the incidence of predators in relation to different densities of lac insect of both *kusmi* and *rangeeni* strains raised on different host plants have shown that, in general, the incidence of the predators increased with the increase in the density of lac insects.

1.3.4 The insecticidal control schedule developed at this Institute, involving Thiodan® and Thuricide® for the control of lac predators has been found to have no adverse effect on economic attributes of *K. lacca*; but, an increase in the fecundity of lac insects has been observed.

1.4.1 All the integrated pest control schedules tried were found effective to varying degrees. The insecticide endosulfan, in general, was found to be highly effective in case of *rangeeni* crops, in respect of yields and predators' suppression although distinct correlation between the two parameters was not discernible. In case of *kusmi* crop in general, combination of endosulfan and *Bacillus thuringiensis* (*B.th*) (1:1) proved highly effective followed by pure sprays of endosulfan alternated with *B.th.* or combination sprays. The study has also revealed that the concentration of endosulfan can profitably be increased only up to 0·075 percent.

1.4.2 Inexpensive cultural methods for the control of the lac insect predators have been devised: (i) trap cropping, i.e. the raising of a heavy density crop (harvested as *ari*) to trap the pests along with a main crop of low density (ii) phenological method, involving delay of the date of inoculation to asynchronize the host pest cycles (iii) use of brood lac containers made of 60-mesh synthetic net instead of wire-netting containers to trap the pests emerging from the brood lac and thereby reducing the expenditure on containers from Rs 2.50 to Rs 0.75 per container (iv) exposing the scraped *phunki* lac to sunshine for two hours only to kill the lac predators to prevent carry-over effect and the loss during storage.

1.4.7 Studies have shown that the avoidable loss of sticklac is 71·8, 65·9, 38·9 and 20·4 percent for the *katki*, *aghani*, *baisakhi* and *jethwi* crops respectively, implying that crop protection measures are obligatory for the *katki* and the *aghani* and discretionary for the *baisakhi* and dispensable for the *jethwi*.

The difference in the percentage of avoidable loss has been 6-25 percent less under chemical protection compared to mechanical protection revealing the scope for improvement.

1.5.2 Study of crosses of the *rangeeni* and *kusmi* strains of lac insects has shown that their differences in rearing period, resin secretion and resin dye-level are genetic and have provided evidence of considerable hybrid vigour. The performance of the F_1 hybrid females, however, differed with the direction of the cross and those with *kusmi* as the maternal parent performed even better than the superior parent (*kusmi*).

(b) RESEARCHES ON HAND

1.2.1 Trials made to feed the larvae of lac predator *E. amabilis* on diets incorporating proteins, amino acids and fats extracted from lac insects could not be carried out due to load sheding. This project has now been kept in abeyance.

1.2.2 Efforts made to improve the agar agar substrate, tried earlier for artificial rearing of lac insects, through incorporation of soft wax and using gelatin as a substitute did not meet with success.

Attempts were also made to obtain the phloem sap from *bhalia* shoots but without success.

Lac insects reared on agar agar substrate showed improved performance by changing the frequency of diet administration and improving the substrate consistency and texture through refrigerated cooling.

1.2.3 Attempts made to kill the lac insect microflora were not successful with the foliar application of the antibiotics. The incorporation of antibiotics in the diet, however, killed the lac insect microflora and also the lac insects suggesting that the lac insect microorganisms play a symbiotic role.

1.2.4 Crude sex pheromone, extracted from the abdominal tips of the female of *E. amabilis*, was found effective in attracting the virgin males.

1.3.3 Experiments carried out earlier for inducing mating were repeated with similar results.

1.3.5 Investigations were continued at the Regional Field Research Station, Dharamjaigarh for supplementing *kusmi* lac production in the region.

1.3.6 This study has shown that the lac larval density differed significantly between canopies and between quadrants but not within canopy between trees. The survival of lac insects was better in the upper canopy than in the lower but this difference was not discernible with the progress of the crop. The incidence of the lac predators was higher in the lower canopy than in the upper and *E. amabilis* was more prevalent than *H. pulverea*.

1.3.8 Preliminary sampling in the *katki* crop has shown that substantial loss is suffered by the post-metamorphic females due to predation and parasitisation which were found to be equally important at this stage.

In the following *baisakhi* crop, losses were estimated due to non emergence, dislodging due to weather and mortality during settlement of lac larvae and the loss was heaviest while attempting settlement.

No evidence was discernible for the intra tree variation in the lac larval density.

1.3.9 The larval settlement has been studied in relation to the inclination of shoot from the ground level which has suggested that the lac insects prefer shade for their settlement.

1.4.3 A number of synthetic insecticides were screened for their safety to one or two stages of lac insects in all the four lac crops. The results have not provided any consistent trend.

1.4.4 Pure and mixed isolates of pathogenic microorganisms obtained from the diseased predators were not found to be highly virulent.

1.4.8 The study has been kept in abeyance.

1.4.12 The studies have been planned.

1.5.5 Cytological studies of the lac insect have confirmed a ' Lecanoid ' system of chromosome behaviour. Studies on spermatogenesis were also carried out.

1.5.7 Electrophoretic studies have shown that presence of three isozymes of tetrazolium oxidase in the *rangeeni* lac insect as was also found in the *kusmi* insect earlier. Glucose-6-phosphate dehydrogenase was found to be present as a monomorphic protein in both *rangeeni* and *kusmi* strains of lac insects. Two stocks of *rangeeni* strains were studied for their proteins using disc gel electrophoresis and were found to differ in this respect.

1.5.8 A number of *rangeeni* and *kusmi* stocks of lac insects were maintained and evaluated for their economic qualities. The Orissa *kusmi* stock was found to secrete maximum resin of the lightest colour. The stocks originating from the north-eastern region were found to differ significantly from the *rangeeni* and *kusmi* strains in their rearing periods and resin dye level.

1.5.10 Study of the sex-ratio in individual progenies of a *rangeeni* and a *kusmi* stocks and a F_2 of their cross have provided evidence of genetic variation in sex-ratio and progeny size and shown a consistent trend for the male proportion to increase with the increase in the size of the progeny. An interesting feature has been the record of occasional occurrence of unisexual progeny of either sex.

Operational Research Project

The work carried out under the Operational Research Project, being implemented in four tribal villages of Ranchi which included various demonstrations of improved technologies for lac culture, apiculture, agriculture and horticulture besides extension education programmes for the overall economic upliftment of the area.

B. AGRONOMY AND PLANT GENETICS DIVISION

(a) RESEARCHES COMPLETED

2.1.5 *Kusum* plants could be successfully propagated through air-layering in June with the help of plant growth regulators. The combination of IBA+IAA at 100 ppm was found best in establishing maximum number of rooted air-layers.

(b) RESEARCHES ON HAND

2.1.2 The different planting systems had no significant effect on the plant growth characters. The combination of urea and SSP at normal and double normal doses showed marked influence on plant growth.

2.1.3 *Expt.* 1 — Out of four fodder grasses grown as inter crops in between *bhalia* and *galwang*, Dinanath gave highest forage yield as compared to the others. Indirect effect of fertiliser applied to the inter crops was noted on the plant growth of *bhalia* and *galwang* bushes.

Expt. 2 — The total shoot length of *bhalia* during 1979 was found maximum wherein sweet potato+ginger+turmeric were grown as intercrops, whereas it was best in *galwang* with sweet potato+turmeric. During 1980, total shoot length of *bhalia* and *galwang* was, however, best with sweet potato+turmeric.

Expt. 3 — Of the intercrops grown, between and within *palas* bushes, Dinanath, an annual fodder grass, gave the maximum forage yield. The maximum net return was found with the intercropping of Dinanath+turmeric+tapioca during both the years.

2.1.4 *Expt.* 3 — Foliar spray of NAA at 80 ppm on *ber* bushes showed the maximum plant height, number of branches and diameter of stems during 1979 but in 1980 GA_3 at 160 ppm showed best results.

Expt. 5 — Foliar spray of GA_3 at 80 ppm+urea(1%) on *kusum* plants showed the best results with regard to shoot length during the period under report.

2.2.1 The flowering period of *M. macrophylla* was delayed up to February by pinching and topping treatments. The length of pollen tube of *M. chappar* was measured as 30·72 to 143·36 μ during the receptivity of stigma.

Stigma receptivity of *M. macrophylla* tested under field condition showed that the pollination before 24-26 hr of anthesis was found suitable for 60 per cent fertilization.

2.2.2 The plants raised in progeny rows were inoculated for raising *aghani* 1979-80 crop which, however, was damaged by lac predators. These plants were again inoculated for raising *aghani* 1980-81 crop. About 30 per cent plants died due to the damage in the root systems of *Bhalia* bushes by a white grub.

2.2.3 Minimum reduction in pulse yield due to lac inoculation was noted in varieties No. 3570 and T-21. Maximum lac yield per plant was found in varieties ICP nos. 6986, 7188 and 6344.

Among the varieties raised for lac inoculation, ICRISAT ICP nos. 6344, 7119 and No. 3570 were found better with respect to plant survival whereas maximum brood lac was recorded from *Basant*.

Another set of plants raised during June 1980 showed that the maximum and minimum space for lac inoculation was provided by ICP Nos. 6344 and 8501 respectively. Plants inoculated during October to raise *baisakhi* 1980-81 crop were growing well till the period under report.

2.2.4 Seeds of *arhar* (*Assam* cv) sown after irradiating them with gamma rays showed that the germination and survival percentage decreased with the increase in doses in M_1 generation. Seeds collected from individual plant were used for raising M_2 generation and plants were put under lac inoculation to raise *baisakhi* 1980-81 crop which was developing well till the period under report.

C. CHEMISTRY DIVISION

(a) RESEARCHES COMPLETED

3.1.4 The study has resulted in the isolation and identification of nearly 80 percent of the constituent acids of hard resin of lac. Nearly 2·7 percent free aldehydic and 10·7 percent free fatty acids are present in lac resin. It has been further concluded that hard resin is composed of aliphatic and terpenic acids in the ratio of 1:1 nearly.

3.1.5 A method has been developed for the estimation of shellac in presence of other natural resins by carrying out hydrolysis under specified conditions and separating out water soluble aldehydic acids which are estimated either by sodium sulphite addition or visible abosrption. The mixtures with other natural resins give values in direct proportion to the amount of shellac present in them. Shellac in an admixture more than 5 percent could be estimated.

3.2.4 The unsaturated esters of aleuritic acid namely, allyl aleuritate, aleurityl crotonate and aleurityl cinnamate were prepared by the condensation method and their polymerization was affected by the free-radical initiation. The resultant compounds obtained in small quantities were of low molecular weights.

3.3.9 Suitability of shellac as a binder-cum-fuel for solid rocket propellants was studied. A number of shellac based propellants were prepared and tested for their physical, mechanical and burning properties. It was found that the propellants burnt smoothly with a high flame and left no ash. They possessed good mechanical properties except adequate flexibility. During static firing experiments in a rocket motor, they burnt smoothly without chuffing and gave a good thrust.

3.4.6 A two pack composition based on lac-linseed oil-glycerol and toluene diisocyanate has been developed which can be used for the gas holder of a gobar-gas plant and protects it against corrosion for more than a year thereby increasing its life. The composition does not need a primer. The covering power and cost of the coating work out to 12 sq. m and Rs 40 per litre (December, 1980).

3.5.2 Physico-chemical studies on lac were carried out for determining its suitability as a wall material for encapsulation.

Studies on solubility parameter suggest that shellac may be used as a suitable class III type of wall material having a number of polar groups. This would help in choosing solvent/core/shellac wall capsular combination. Shellac-solvent interaction parameter shows that ethyl alcohol is most suitable for organic phase-separation, polymer incompatibility and fluidised bed encapsulation. The physico-chemical studies on aqueous shellac solutions and hydrosols suggest that both de-waxed and normal shellac are suitable as wall material in hydrosol form for encapsulation. Dialysis studies show that any type of shellac may be used for hydrosol formation.

A simple and new method based on resin concentration or *p*H or volume of diffusate for determining the optimum time of dialysis has been found out. Physico-chemical properties of dispersed phase in hydrosols reveal that hard resin of shellac is responsible for acid colloid characteristics. Studies on water sorption and permeability of shellac suggest that both are interdependent and environmental factors have significant effect on them. The electrophoretic mobility shows that shellac behaves as a hydrophillic acid colloid and may be used in *p*H-coacervation process of encapsulation.

3.6.2 The effect of seven commonly used plasticizer on the dielectric strength of shellac (dewaxed) varnishes was investigated. Shellac varnishes containing 20 percent of plasticizers like ICP, DBP and DMP could be used as general purpose air-drying shellac varnishes. The dielectric strengths of these varnishes were found to be 2·0, 1·76 and 1·7 kV/mil respectively as compared to 1·0 kV/mil for plain shellac varnish. Shellac-DMP varnish passed the test for resistance to transformer oil. It was observed that the presence of shellac-wax in the varnish is undesirable.

(b) RESEARCHES ON HAND

3.1.2 *Separation and study of components of lac wax*

Two pure compounds have been isolated (m.p. 81-82°C, Rf value 0·08 and m.p. 79-80°C, Rf value 0·85) from ether insoluble fraction B-1 which was obtained from alcohol insoluble wax fraction (B) at 40°C. The former appeared to be an alcohol while the latter a hydrocarbon.

3.1.6 *Correlation of the properties of seedlac and shellac with age*

A deterioration has been noticed in most of the physical properties of seedlac and shellac on storage.

3.1.7 *Improvement in the method of isolating aleuritic acid from lac for maximizing its recovery*

The approximate cost of production of aleuritic acid per kilo has been worked out following the conventional method of alkaline hydrolysis. The study indicates that *kiri* which is cheaply available and contains good amount of lac can also be exploited to manufacture aleuritic acid. Aleuritic acid has been prepared in bulk from seedlac and shellac (10 kg. lot) adopting the conventional alkaline hydrolysis method.

The addition of sodium sulphite during saponification of lac enhances the yield of aleuritic acid by 3 to 5 percent.

3.1.8 *Spectrophotometric studies on lac*

The absorption spectra of eight dewaxed varieties of shellac having various colour indices and of bleached lac have been studied in the complete U.V. and a visible region and the following relation-ship between colour index and optical density (at 425 nm) has been established for concentration 10^{-3} g/ml (solvent : ethyl alcohol) colour index = 136·9 × optical density.

Further, the absorption spectra of hard and soft fractions of lac and their different admixtures have also been investigated. The spectra of 70 : 30 hard-soft mixture were not identical to those of parent shellac in the U.V. range.

3.2.1 *Syntheses of exaltone, isoambrettolide and prostanoid synthon*

The syntheses of exaltone, isoambrettolide (cis and trans) and synthon have been carried out in quantity from aleuritic acid.

3.2.2 *Syntheses of civetone and cyclic ureides from aleuritic acid*

Ureides have been synthesized from Δ^9-heptadecene-1,17 and Δ^9-hexadecene-1,16 dioic acids obtained from aleuritic acid by refluxing their diethyl esters with urea in presence of sodium ethoxide.

3.3.6 *Ion exchange resin from shellac*

With a view to cheapen the product, cashew nut shell liquid was employed in combination with resorcinol in various proportions for the preparation of cation exchange resin. It was observed that as the amount of CNSL increased, the resin obtained showed lowering in yield and cation exchange capacity.

After suitable modification of the treatment techniques, one litre of sample of cation exchange resin has been prepared for evaluation.

3.3.8 *Modification of lac/hydrolysed lac with glycols and dicarboxylic acids*

Hydrolysed lac has been reacted with ethylene glycol and dicarboxylic acids such as adipic, maleic, phthalic and terephthalic in different proportions. The polyesters, thus obtained, have been further reacted with toluene diisocyanate to give polyurethanes whose film properties have been studied.

3.3.11 *Modifications of lac with unsaturated acids*

Shellac has been modified with unsaturated acids such as maleic and acrylic. The surface coating and adhesive properties of modified shellac compositions are under study.

3.3.12 *Addition polymerization of shellac*

An attempt was made to bring about addition polymerisation of shellac in alkaline medium using potassium persulphate as an initiator. No conclusion however, could be drawn.

3.4.3 *Studies on lac-oil combinations and their utilization*

Two litres of lac-double boiled linseed oil varnish has been prepared in six lots for testing special properties and also for evaluation by prospective consumers. A local consumer has reported that the varnish which was applied in a 2 h.p. motor of an air compressor is working satisfactorily for the last one year.

3.4.7 *Shellac paints for wood patterns*

Paints based on lac-melamine resin, lac-ethyl cellulose and lac-melamine resin-nitrocellulose as binder have been prepared and tested for their film properties such as drying chracteristics, gloss, hardness, adhesion and resistance to water and to the action of wet sand. Paints prepared from lac-melamine resin have been found to possess maximum gloss. No change in any of the film properties was noticed on storage for an year.

3.4.8 *Studies on shellac esters and their utilization*

The esterification of aleuritic acid with methanol has been studied and the same has been found to be complete in 2 hr.

3.5.1 *Coating of insecticides and pesticides with lac*

For finding out the utility of shellac as a wall material, a few pesticides such as Phorate, Thimet and Dimethoate have been encapsulated and sent to Kerala and Tamil Nadu Agricultural Universities for evaluation. The samples of dialysed shellac and gelatin which were sent to Rodent Research Centre, Jodhpur for palatibility trials on rodents have revealed that dialysed shellac is acceptable to rodents indicating the suitability of shellac as a wall material for encapsulation of rodenticides.

3.5.3 *Slow-release chemically combined lac-based weedicides*

With a view to develop a slow-release selective and preemergent type of lac-2, 4-D weedicide combination product for the control of *Parthenium* and other weeds of agricultural crops, shellac has been combined by direct fusion method as well as with the acid chloride of 2,4-D in three molar proportions in homogeneous reaction system. The results reveal that the ester combination takes place in 1:1 and 1:2 molar proportions. The samples of lac-2,4-D ester prepared through direct combination have been sent for preliminary evaluation.

3.6.3 *Curing behaviour of shellac-synthetic resin composites by dielectric measurements*

The curing between the functional groups of shellac (DL) and epoxy resin (mol. wt 1000 and 500) has been investigated by studying the variation dissipation factor, conductivity, dielectric strength and specific viscocity of different shellac-epoxy compositions with time in the cold. It has been found that most of the curing takes place within first six days after their blending.

3.7.1 *To prepare a standard for lac dye for use as a food colour*

Some of the characteristics of lac dye obtained from *palas* and *kusum* stick-lacs, have been determined.

A sample of lac dye has been sent to the Central Food Laboratory, Calcutta for carrying out toxicity tests.

3.7.2 *To prepare standard for different grades of lac wax*

Different characteristics such as acid, saponification and iodine values and also resin content of three samples of lacw ax obtained from M/s Waxpol Industries, Tatisilwai have been determined.

D. TECHNOLOGY DIVISION

(a) RESEARCHES COMPLETED

4.1.1 A process has been developed for preparing regular and dewaxed lac by aqueous method. The dewaxed lac was found suitable for the preparation of water soluble lac and insulating varnish.

4.1.5 (i) It was observed that the darkening effect on seedlac due to drying in sun depends on the method of washing and duration and temperature of sun drying.

4.3.1 (iii) A suitable adhesive composition based on aqueous alkaline solution of seedlac and hydrolysed lac has been developed for pasting paper to paper and paper to other surfaces such as glass, metal, plastic, wood, cloth.

(b) RESEARCHES ON HAND

4.1.5 (i) By using synthetic detergents as washing aid for sticklac, it was observed that the yield of seedlac improved accompained by reduction in colour and bleach index over the conventional washing aid-sodium carbonate.

4.1.6 (i) A method of dewaxing lac in aqueous medium on semi pilot scale was standardised and the wax content of the product was found between 0·11 and 0·14 per cent.

4.1.6 (ii) Work has been initiated to remove the difficulties experienced during filtration for dewaxing and decolourizing lac solution.

4.2.1 The abrasion resistance of NR-SBR blend in presence of EPC and HAF fillers was found to decrease by the incorporation of shellac. Zinc-salt (5 parts) in the blend in presence of HAF filler improved the abrasion resistance. Flexing improved with zinc-salt of lac (5 parts) in presence of both the fillers.

4.3.1 (ii) Bleached lac was modified with methyl and ethyl acrylates and the resulting product has shown a promise as an adhesive for fixing sunmica over wooden surface.

4.3.2 An attempt was made to use shellac butylated melamine resin and shellac-acrylate combinations for top coats to get surface resistance but did not prove successful. However, urea resin alone gave encouraging results.

4.3.3 Bigger insulating sheets (30 cm×30 cm) were prepared using calcined mica with modified shellac as a bonding material and their properties determined.

4.3.4 Preliminary experiments have indicated that only one epoxy group could be introduced in the *total* hydrolysed lac.

7. METEOROLOGICAL REPORT FOR THE YEAR 1979

The average meteorological data for each month were as follows:

Month	Mean barometric pressure (mm)	Mean maximum temp. (°C)	Mean minimum temp. (°C)	Mean dry bulb temp. (°C)	Mean wet bulb temp. (°C)	Mean humidity (%)	Mean sunshine (hr/day)	Total rainfall (mm)	Highest maximum temp. (°C)	Lowest minimum temp. (°C)
January	710·05	25·08	10·60	19·08	14·39	61·25	6·61	33·3	28·0	5·5
February	708·04	24·60	11·75	17·16	13·58	67·42	7·28	75·7	30·0	6·6
March	705·68	31·67	15·65	21·77	16·09	51·45	8·0	13·1	37·0	8·8
April	703·08	36·43	20·87	28·15	20·13	47·01	8·31	24·2	39·5	18·3
May	701·24	38·93	24·27	31·90	21·62	40·00	9·27	0·7	43·0	21·1
June	698·65	36·98	24·31	31·42	24·53	59·11	Paper not available	209·4	42·0	20·0
July	698·95	31·91	23·41	27·41	24·89	82·24	do	312·3	38·0	22·2
August	699·00	31·37	23·14	26·51	24·35	84·22	do	209·6	34·5	21·0
September	702·46	32·4	22·44	27·1	24·5	80·25	do	149·8	34·0	21·0
October	706·00	32·5	18·2	27·3	22·2	61·8	do	59·3	36·0	16·0
November	710·20	30·6	16·6	24·6	22·8	85·0	6·2	26·0	32·5	12·7
December	710·00	25·4	10·6	18·8	14·4	61·0	6·7	11·3	30·5	7·2

The highest maximum temperature recorded was 43·0°C on 10th May and the lowest minimum temperature 5·5°C on 2nd January. The total rainfall during the year amounted to 1124·5 mm of which the monsoon (June to Sept.) rainfall was 881·1 mm. The rainfall during the year was lower than that of 1978 (1620·1 mm). There were hail-storms on 26th March and 17th April.

7. METEOROLOGICAL REPORT FOR THE YEAR 1980

The average meteorological data for each month were as follows:

Month	Mean barometric pressure (mm)	Mean maximum temp. (°C)	Mean minimum temp. (°C)	Mean dry bulb temp. (°C)	Mean wet bulb temp. (°C)	Mean humidity (%)	Mean sunshine (hr/day)	Total rainfall (mm)	Highest maximum temp. (°C)	Lowest minimum temp. (°C)
January	709·37	25·30	9·61	17·8	13·8	63	5·6	11·2	30·0	5·0
February	708·30	26·6	12·9	21·1	13·6	41	Paper not available	12·0	34·0	5·5
March	706·84	29·0	16·8	23·4	19·2	67	do	30·0	38·0	12·2
April	703·39	38·2	22·2	30·7	21·0	41	do	50·17	42·0	17·7
May	700·69	40·0	24·2	30·5	23·5	55	do	114·7	43·0	20·5
June	698·34	32·4	19·9	26·9	24·7	82	do	303·31	37·5	21·6
July	698·01	30·3	23·1	25·9	24·6	89	do	423·0	35·5	22·7
August	699·2	29·9	23·1	25·8	24·4	89	do	243·0	32·0	21·6
September	679·11	30·5	22·3	25·0	24·0	92	do	306·6	33·0	18·8
October	705·60	32·2	18·3	24·8	21·6	75	do	48·0	33·5	13·8
November	685·30	28·1	13·4	20·8	16·4	63	do	Nil	30·5	10·5
December	709·11	25·0	10·4	17·2	13·3	64	do	3·1	28·5	7·2

The highest maximum temperature recorded was 43·0°C on 6th, 7th, 8th and 20th May and the lowest minimum temperature 5°C on 10th January. The total rainfall during the year amounted to 1545·38 mm of which the monsoon (June to Sept.) rainfall was 1275·91 mm. The rainfall during the year was higher than that of 1979 (1124·5 mm). There were hail storms on 27th, 31st March and 2nd May.

PERSONNEL

Sl No.	Name of the Posts	Staff position as on 31-12-1980
1.	Director	Dr. T. P. S. Teotia
	Entomology Division	
1a.	Head, Division of Entomology	(1) Dr. R. L. Tripathi up to 7-2-80 (2) Sri N. S. Chauhan w.e.f. 8-2-80
2.	Scientist S-3 (Agricultural Entomology)	Shri N. S. Chauhan up to 7-2-80
3.	Scientist S-2 (Agricultural Entomology)	(1) Dr. B. P. Mehra. Expired on 16-1-79 Vacant from 17-1-79 (2) Dr. C. P. Malhotra (3) Sri A. H. Naqvi (4) Sri R. C. Mishra
4.	Scientist S-1 (Agricultural Entomology)	(1) Sri S. G. Choudhary (2) Dr. A. K. Sen (3) Sri B. N. Sah (4) Dr. D. C. Srivastava (5) Sri S. K. Jaipuriar (6) Sri A. Bhattacharya (7) Sri R. Ramani (8) Sri Y. D. Mishra
5.	Scientist S (Agricultural Entomology)	(1) Sri M. L. Bhagat (2) Sri Jawahir Lal
6.	Senior Technical Assistant (T-4)	(1) Sri J. M. Dasgupta (2) Sri M. K. Chowdhary
7.	Technical Assistant (T-II-3)	(1) Sri A. K. Sahay (2) Sri K. U. S. Sinha (3) Sri R. N. Vaidya (4) Sri H. Bhengra (5) Sri L. C. Nath Sahadeo
8.	Senior Artist (T-4)	Sri R. L. Singh
9.	Junior Artist-cum-Photographer (T-1)	Sri R. P. Srivastava
10.	Laboratory Technician (T-2)	(1) Sri B. B. Chakravorty (2) Sri G. M. Borkar (3) Sri Ajmer Hussain
11.	Laboratory Technician (T-1)	(1) Sri S. K. Chatterjee (2) Smt. Santoshi Minz (3) Sri Bhola Ram (4) Sri Ghanshyam Das
12.	Field Technician (T-2)	(1) Sri R. S. Maliya (2) Sri H. R. Munda (3) Sri K. C. Jain (4) Sri S. S. Prasad (5) Sri R. D. Pathak
13.	Field Technician (T-1)	(1) Sri H. N. Shukla (2) Sri Jiwan Lal
14.	Insect Collection Tender (T-1)	Sri Ram Lochan Ram
15.	Field Plantation and Store Assistant (T-1)	Sri Munna Lal Ravidas
16.	Junior Stenographer	Sri Sant Kumar

Agronomy and Plant Genetics Division

1.	Agronomist	Vacant
2.	Scientist S-2 (Plant Genetics)	Dr. P. Kumar
3.	Jr. Arboriculturist (S-1)	Vacant
4.	Scientist S-1 (Plant Breeding)	Sri S. C. Srivastava
5.	Scientist S-1 (Horticulture)	Dr. Moti Ram
6.	Scientist S-1 (Agronomy)	Sri B. P. Singh
7.	Laboratory Technician (T-2)	Sri D. D. Prasad
8.	Field Technician (T-1)	Sri Jagarnath Oraon

Chemistry Division

1.	Head, Division of Chemistry	Sri Shravan Kumar
2.	Scientist S-3 (Organic Chemistry)	Dr. B. B. Khanna
3.	Scientist S-2 (do)	(1) Dr. S. C. Agarwal
	(Physical Chemistry)	(2) Dr. A. Kumar
4.	Scientist S-1 (Organic Chemistry)	(1) Sri A. K. Dasgupta
	(Physical Chemistry)	(2) Dr. D. N. Goswami
	(Organic Chemistry)	(3) Dr. B. C. Srivastava
	(do)	(4) Dr. N. Prasad
	(do)	(5) Dr. R. N. Majee
	(do)	(6) Dr. K. Mohan
	(do)	(7) Sri K. M. Prasad
5.	Scientist S (do)	(1) Sri M. Mukherjee
	(do)	(2) Sri P. M. Patil
6.	Senior Technical Assistant (T-4)	Sri A. Rahman
7.	Technical Assistant (T-II-3)	(1) Sri N. K. Dey
		(2) Sri M. K. Mishra
		(3) Sri T. K. Saha
		(4) Sri M. Ekka
		(5) Sri D. D. Singh
		(6) Sri S. N. Sharma
8.	Laboratory Technician (T-2)	(1) Sri U. Sahay
		(2) Sri B. P. Keshri
9.	Laboratory Technician (T-1)	(1) Sri P. B. Sen
		(2) Sri G. Mishra
		(3) Smt. Prabha Devi
10.	Glass Blower	Vacant
11.	Junior Stenographer	Sri B. K. Rajak

Technology Division

1.	Scientist (S-2) (Organic Chemistry)	Dr. P. C. Gupta
2.	Jr. Technologist (Processing S-1)	Sri A. K. Ghosh
3.	Scientist S-1 (Organic Chemistry)	(1) Sri R. K. Banerjee
	(Physical Chemistry)	(2) Sri Radha Singh
4.	Senior Mechanic (T-II-3)	Sri S. K. Bhaduri
5.	Senior Technical Assistant (T-4)	(1) Sri M. Islam
		(2) Sri B. P. Banerjee
		(3) Sri R. Prasad
6.	Technical Assistant (T-II-3)	Sri K. K. Prasad
7.	Laboratory Technician (T-2)	(1) Sri N. Minz
		(2) Sri M. K. Singh
8.	Laboratory Technician (T-1)	Sri Tulsi Ram

Extension Division

1.	Scientist S-3 (Physical Chemistry)	Dr. S. K. Saha
2.	Scientist S-1 (Organic Chemistry)	Dr. A. Arya
3.	Scientist S-1 (Agricultural Entomology)	Sri R. S. Gokulpure
4.	Scientist S-1 (Physical Chemistry)	Dr. A. Pandey
5.	Senior Analyst (T-5)	Sri L. C. Mishra

6.	Senior Technical Assistant (T-4)	Sri R. C. Maurya
7.	Commercial Artist (T-II-3)	(1) Sri Pyare Das
8.	Technical Assistant (T-II-3)	(1) Sri Deepak Ghosh
		(2) Sri K. M. Sinha
		(3) Sri Jagdish Singh
9.	Laboratory Technician (T-2)	(1) Sri D. Runda
		(2) Sri B. P. Ghosh
10.	Museum Assistant (T-2)	Miss P. R. Chatterjee
11.	Junior Stenographer	Sri A. K. Sinha

Administrative, Audit and Accounts Section

1.	Administrative Officer	Vacant
2.	Assistant Administrative Officer	Sri S. N. Sharma
3.	Assistant Accounts Officer	Vacant
4.	Superintendent	(1) Sri S. N. Prasad
		(2) Sri R. K. Singh
5.	Assistants	(1) Sri P. K. Chowdhary
		(2) Sri D. P. Sengupta
		(3) Sri H. S. Munda
		(4) Sri R. P. Singh
		(5) Sri Musafir Singh
		(6) Sri Enamul Haque
		(7) Md. Shamiullah
		(8) Sri A. K. Lal
6.	Senior Stenographer	Sri R. Rabidas
7.	Senior Clerk	
		(1) Sri N. Mahto
		(2) Sri A. K. Chowdhury
		(3) Sri Elias Tirkey
		(4) Sri S. K. P. Keshri
		(5) Sri A. Haque
		(6) Sri R. B. Singh
		(7) Smt. Sati Guha
		(8) Sri K. N. Sinha
		(9) Sri K. D. Pandey
		(10) Sri S. Ram
		(11) Sri D. Ram
8.	Senior Clerk (Estate)	Sri D. N. Mahto
9.	Junior Stenographer	Smt. Sushanti Minz
10.	Junior Clerk	(1) Sri K. L. Choudhury
		(2) Sri R. K. Upadhaya
		(3) Sri Budhan Ram
		(4) Md. Mubarak
		(5) Sri N. Topno
		(6) Sri V. Ram
		(7) Sri E. Gari
		(8) Sri J. P. Srivastava
		(9) Sri N. Gope
		(10) Sri Lakshmi Kant
		(11) Sri Thibu Minz
		(12) Sri B. N. Gope
		(13) Sri K. P. Gupta
11.	Stockman-cum-Compounder	Sri Chandreswar Pandey

Project File and Technical Cell

1.	Junior Technical Officer	Sri S. K. M. Tripathi
2.	Senior Technical Assistant (T-4)	Sri P. Sen

Library

1.	Senior Library Assistant	Sri R. P. Tiwari
2.	Library Assistant	Sri V. K. Singh

Maintenance and Workshop Unit

1.	Chief Mechanic	Sri S. K. Srivastava
2.	Assistant Mechanic	Vacant
3.	Instrument Maker	Vacant
4.	Turner (T-1)	Sri A. S. Manoranjan
5.	Driver for vehicle	(1) Sri J. Ram (2) Sri Bandhan Runda (3) Sri M. Khalko

Institute Plantation

1.	Farm Superintendent	Sri B. K. Purkayastha
2.	Field Farm Technician (T-2)	(1) Sri G. Lakra (2) Sri Md. Ali Ansari
3.	Tractor Driver	Sri Markus Surin

Mixed Plantation Scheme at Chandwa

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

PRINTED AT THE CATHOLIC PRESS, RANCHI, INDIA