INDIAN LAC RESEARCH INSTITUTE

NAMKUM, RANCHI, BIHAR, INDIA

ANNUAL REPORT

FOR THE FINANCIAL YEAR 1944-45.

1945

CONTENTS

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ANNUAL REPORT FOR THE YEAR 1944-45

ADMINISTRATIVE SECTION.

General.—The difficulty in getting requisite supplies of chemicals and apparatus, referred to in the last report, was accentuated during the year under review. This, together with the absence of Dr. H. K. Sen on leave finally ending in his resignation and the depleted strength of one section or another due to the resignation of some of the senior assistants in this and in the previous year, has no doubt been reflectd in the somewhat diminished output of work. Taking, however, into account the very exceptional nature of the period under review, the work may be considered satisfactory on the whole.

As usual, the Institute attracted a large number of visitors, among whom the following deserve special mention :

Director of Industries, C. P. & Berar; The Inspector of Factories, Bihar; The Secretary, Joint Public Service Commission for Bihar, C. P. & Berar, and Orissa; Dr. M. L. Bhatia, M. Sc., Ph. D. (Cantab.), Entomologist to the Government of Bihar; Mr. B. N. Sinha, Deputy Director of Agriculture, Bihar.

Inspection of the Entomological Section.—As mentioned in the previous report, the inspection of the section was finished in 1943-44. The Inspectors' Report was submitted during the period under review and is now awaiting detailed examination by the Committee although the main principles have been discussed with a view to draw up a modified research programme in the light of the Inspectors' recommendations.

Roads and Buildings.—No new constructions, nor any major repairs were undertaken. Only urgent petty repairs and whitewashing of buildings were carried out.

Library.—The prevailing conditions have interfered with the regular receipt of books and journals. The total accession during the year was 296 volumes of which 182 were bound volumes of journals.

Medical Aid.—Medical aid was rendered to the staff as usual.

Staff.—The most important change to note under this head is the resignation of Dr. H. K. Sen, the former Director, with effect from 21-5-44.

The following appointments were made during the year.

(1) Dr. P. K. Bose, D. Sc., F. N. I., as Director of I. L. R. I.
(2) Mr. S. Basu, M. Sc., as Physical Chemist (Class II Research Assistant).
(3) Mr. P. R. Bhattacharya, M. Sc., as Chemist (Class II Research Assistant).
(4) Mr. K. N. Sinha as Assistant Mechanic *vice* Mr. A. S. Bhatta.
(5) Mr. B. K. Sahu as Typist-clerk (Temporary in a leave vacancy)

(6) Mr. S. K. Sircar as Temporary Clerk *vice* Mr. S. K. Narayan.
(7) Mr. H. R. Munda, as Laboratory Assistant (Entomological Sec.)
(8) Mr. K. K. Sircar as Temporary Clerk in a leave vacancy.
(9) Mr. L. M. Sahu as Turner in a leave vacancy.
(10) Khudu Oraon *vice* Jatia Oraon (deceased) as Chaprassi.
(11) Bulua Ram as Chaprassi in a leave vacancy.
(12) Sahadev Ram as Chowkidar *vice* Sheikh Rajjoo.
(13) Harihar Pandey as Peon.

The following members left the services of the Committee :

(1) Dr. H. K. Sen, Director, I. L. R. I.
(2) Mr. M. Rangaswami, Senior Chemical Assistant.
(3) Mr. A. K. Thakur, Senior Chemical Assistant.
(4) Mr. A. S. Bhatta, Assistant Mechanic *vice* Mr. J. C. Bose.
(5) Mr. S. K. Narayan, Temporary Clerk.
(6) Gaya Dutt Misra (Peon).
(7) Sheikh Rajjoo (Chowkidar).

Mr. S. K. Bharadwaj, who had rejoined on the termination of a previous lien, was allowed to take up war service and retain a lien on his post of Museum Assistant & Insect Setter. Mr. C. Tirkey too has got an appointment under the Defence Services and has been granted a lien on his post of Laboratory Assistant.

It is noted with regret that Mr. G. B. Thapa, Accounts Clerk, and Jatia Oraon, a Chaprassi, died during the period under review.

There have been the following cases of promotion in the Institute :—

(1) Mr. G. N. Bhattacharya, M. Sc., promoted substantively to Class I (Chemical Section).

(2) Mr. Y. Sankaranarayanan, M. Sc., promoted to Class I (Chemical Section) in an officiating capacity.

Deputation.—The deputation of Mr. J. M, Sen by the India Paper Pulp Co. Ltd. to investigate the utilisation of by-products of paper mills in conjunction with shellac, was extended for another year.

Supply of foodgrains to members of staff at concession prices.—The supply was discontinued from the 1st January 1945.

The Staff Club.—The activities of the club continued to be limited owing to unavailability of sports goods. Valuable additions have however been made to the library.

CHEMICAL SECTION.

1. MOULDING POWDERS.

(A) Shellac-formaldehyde-urea powders.

Work on further improvements of the shellac-formaldehyde-urea moulding powders particularly in respect of their flow, and the finish and mechanical strength of the moulded articles was continued during the year under review. It has been observed that the comparatively poor flow of the previous compositions was mainly due to the filler particles being too much impregnated with resin during the usual process of making the powder in the steam-jacketed still. A slightly altered process in which the lac-formaldehyde-urea resin solution is first separately made and then mixed in a kneader with fillers, pigments. lubricants etc., the whole mass being rolled and powdered immediately after mixing, results in a powder with better flow from which articles with improved finish and gloss can be moulded.

It has been further observed that in large-scale production, the use of shelf-dryers causes caking and unequal drying in the different portions of the same batch and should therefore be avoided. Drying in a current of hot air or the use of a rotary dryer is necessary to obtain uniform drying.

(B) Fillers.

As the strength of the monlded articles depends to a certain extent on the quality of the filler incorporated in the powders, attention was directed to the standardisation of saw-dusts used for the purpose. It was found that supplies from timber works drawn from different types of wood, even in a condition fine enough to pass 100 mesh, often contained extraneous inorganic matter varying from 2 to 15%. By washing the saw-dust in water, more than once if necessary, the ash content could be reduced for most samples to 1-5%, and only for some, to less than 1%. The moisture content of the saw-dust, which even in cases of apparently dry samples, may be as high as 3 to 10% depending on the season should also be reduced as far as possible by drying the saw-dust if necessary in an oven. The saw-dust thus dried, should be stored in air-tight containers till required. 'Haldu' wood saw-dust is found to impart greater strength to the moulded articles than 'sal', teak or mango wood dusts.

But ordinary saw-dust, though it improves as a result of the above treatments, is much inferior to imported woodflour. This is because of the difference in structure between the two, as observed under the microscope. Commercial saw-dust of Indian origin consists of merely disintegrated particles and lacks fibrous structure such as is possessed by foreign wood-flour and accounts, in a large measure, for the latter's superior performance. Accordingly, attempts were made to defibre it by autoclaving under pressure or alkali digestion. It has been observed that 5-6 hours' boiling with 10% sodium carbonate serves to open up the fibres of the individual particies and the use of such alkali-treated saw-dust, after it has been washed alkali-free and dried, increases the shock resistance by 30-40% as compared with the compostions containing untreated saw-dust.

In order to cheapen the process of preparing the moulding powder from Kiri, the alka li treatment of saw-dust and the recovery of lac from Kiri were combined in one operation, with success on an experimental scale. The process is described below:

5 pounds of Kiri powdered to 30 mesh are extracted hot with 10% sodium carbonate solution and then strained through muslin to remove all insolubles. The soda extract is then mixed with 2½-3 pounds of saw-dust (reckoning that only 2½-3 pounds of lac could be recovered from 10 lbs. of Kiri) and the mixture then boiled for 4-5 hours and cooled. The resin is then precipitated with sulphuric acid and the precipitated mass, admixed with saw-dust, is washed free from acid. The lac-sawdust composition is dried and used for preparing the moulding powder either by the "wet" or by the "hot roller" process. Compositions made by this process have been found to possess good flow and can be moulded into articles with good finish and mechanical strength.

(C) Shellac-cashew shell oil combinations.

Mention was made in the previous annual report of the improvement noted with regard to the water-resistance of the moulded articles obtained by the incorporation, under suitable conditions, of small percentages of cashew shell oil in the lac-moulding compositions. Work on the combination of shellac with cashew-shell oil and its futher modifications with formalin and urea was continued. The optimum proportion of cashew-shell oil, conditions of its treatment before polymerising *in situ*, the temperature and period of reaction in presence of both acid and alkali catalysts before combining with lac and other ingredients were determined. As a result, it has been found that partially polymerised cashew shell oil, made by previously heating the oil at 300°C for 15-20 minutes, when combined in quantities up to 25-30% on the weight of lac during the process of making the lac-formaldehyde-urea moulding powder (the whole being refluxed for 2-3 hours at 70-80°C) gives rise to powders with good flow, which can be moulded into articles with superior finish. Another advantage of using cashew-shell oil is that the powders can be made by the roller-mixing process more easily, as the plasticity of the composition allows for a long time of mixing on the hot rollers, than those without cashew shell oil. Several of these new compositions were made and tested in different moulds, such as 8-impression bottle-cap mould, moulds for shaving bowls, trays etc The impact strength and water-resistance of these compositions were also found to be satisfactory on examination. The heat resistance was rather low, being of the order of 70-75°C (Marten's). Work is in progress to remedy this drawback. It has been observed in the meantime, that the above properties can be considerably improved by baking the articles at gradually increasing temperatures from 80 to 130°C over a period of 12-18 hours.

2. Varnishes and Lacquers.

(a) Manufacture of oil-cloth, book-binding cloth, etc.

It was mentioned in the last annual report that the lac-based varnish for oil-cloth, artificial leather etc., as formulated originally, though otherwise satisfactory, proved defective in that the fabrics coated with it showed a tendency to stiffen gradually and finally to crack during ageing, and that a modified composition (lac-castor oil fatty acid-glycerol-ammonia) was evolved to get over this defect. Samples prepared with this new varnish more than a year ago have retained their original suppleness and surface gloss and have not so far shown any sign of deterioration in this or other respects. A few gallons of this new varnish were sent as samples to a number of enquirers who have acclaimed its satisfactory quality.

(b) Lac-linseed oil-glycerine insulating varnish.

An enquiry was received from a leading firm of electrical Engineers for an insulating varnish (preferably air-drying) suitable for production of "empire" cloth,

varnished tapes etc. As a possible ready-made solution, the oil-cloth varnish mentioned above, was tried for the purpose, but had to be rejected on account of its bad electrical insulating properties. It was therefore considered expedient to study the combination of shellac with linseed oil on the model of copal-oil varnishes. In view of the incompatibility of shellac with linseed oil, the possibility of modifying the linseed oil with glycerine and then combining the lac physically or chemically was investigated. It was found that when double-boiled linseed oil is heated for one hour at 220°C with 20% of its weight of glycerine in a closed kettle provided with an air-condenser and an efficient mechanical stirrer, a reaction product is obtained which dissolves lac (in any form) in 15 minutes at 185-190°C. The oil-glycerine reaction product, prepared by the above method, is found to contain about 8 gms. of uncombined glycerine for every 20 gms. of glycerine used. The uncombined glycerine, however, can be washed out with boiling water, and the residual oil (hereinafter called "treated oil") dried by heating to about 140°C.

The treated oil forms a semi-solid mass during winter, but remains quite fluid during the summer months. The treated oil may be chemically combined with 60% of its weight of lac by heating at 260°C for 1½ hours in a closed vessel fitted with an efficient machanical stirrer and having a small opening for escape of fumes, when the acid value drops down to 3-3·5. The resulting product is completely soluble in turpentine, white spirit and solvent naptha, and also compatible with linseed oil and tung oil. Films of this on glass-slides dry in 72 hours. The drying period could however be considerably reduced by incorporation of small amount of driers, e. g., 0. 5% of cobalt linoleate (on the weight of the oil-lac combination) reduces the period to 24 hours, and 0. 8% of the same drier to less than 8 hours.

Preliminary experiments indicate that air-dried films of this composition are hard, and possess good flexibility, gloss, water-resistance and good electrical insulating properties.

(c) Lac-Cashew shell oil varnishes.

Improvements observed in the electrical insulating properties and water resistance of lac-cashew shell oil varnishes have already been reported (vide Annual Report 1944). As a result of further work on the condensation of shellac with cashew shell oil and co-polymerisation of the same with formaldehyde and urea in presence of various alkali and acid catalysts, the following procedure has been found satisfactory :

Equal proportions of lac and cashew shell oil are heated at 140-150°C for 2-3 hours and dissolved in a solvent, preferably n-butyl alcohol. To the solution are then added 6-8% urea and 25-30% formalin (40%) on the weight of lac and refluxed on a water-bath for 4-5 hours. The solution is then distilled in vacuum to remove the solvent, the excess of formaldehyde and water of reaction. The resulting thick syrupy resin is finally dissolved in equal proportions of spirit and toluene (or xylene). Films from such varnishes after baking at 120-130°C for about an hour or at 100°C for about 3 hours, are glossy, hard, tough and scratch-resistant.

Some of the properties of the baked film of such a varnish observed qualitatively are given below :—

Water	...	No effect for several days.
Boiling water	...	„ effect.
Caustic soda 5%		„ „ „

Sodium carbonate 5%	No effect
Sulphuric acid 5%	„ „
Ammonia 28%	„ „
Dilute acetone up to 35%	„ „
Dilute methyl alcohol up to 30%	„ „
Flexibility	... Quite good.
Dielectric strength :	
At room temperature	... 1500-1600 volts/mil
At high humidity	... 700-800 volts/mil
At 90°C	... 1200-1400 volts/mil

It has also been observed that by initially adjusting the proportions of lac to cashew shell oil before final condensation with formalin and urea, varnishes capable of giving films ranging from highly flexible and supple to hard, brittle and glossy ones could be prepared. The varnishes for flexible films could be used for water-proofing fabrics, paper, etc. and those giving hard ones for producing alkali-and acid-resistant coats on metal etc. Other properties of the film such as tensile strength, abrasion resistance, permeability etc. are being studied. A paper incorporating the above results will be soon ready for publication.

It may be mentioned that all the varnishes described above are rather dark-coloured and may therefore have restricted application. Light-coloured varnishes may, however, be prepared by using the light-coloured cashew shell oil (cardanol) obtained by vacuum distillation of the raw oil at 220-230°C under 15-20 mm. pressure. Such varnishes may be used for preparing light-coloured insulation fabrics ('Empire' cloth) used in electrical industries.

Further experiments on the combination of cashew shell oil with shellac in presence of furfural, phenols, drying and semidrying oils and glycerine and various oxidising agents are in progress. Also, the use of shellac acids for polymerising cashew shell oil is being studied.

A separate report on the insulating properties of varnishes and lacquers will be found in the section "Fundamental researches".

3. ADHESIVES.

It was mentioned in the last annual report that a good heat and water-resistant adhesive, suitable for bonding glass to glass, glass to metal, metal to metal etc. could be prepared by the condensation of hydrolysed lac with maleic anhydride followed up by esterification with allyl alcohol and oxidation by means of benzoyl peroxide. Further work was carried out mainly with a view to replace costly chemicals like maleic anhydride and allyl alcohol by phthalic anhydride and methyl (or ethyl) alcohol respectively. But the new composition is not as good as its predecessor, inasmuch as, besides requiring a longer time for reaction and curing, it is satisfactory only for adhesion of glass to glass, and not for other surfaces. Further work is in progress to improve this composition.

4. FUNDAMENTAL RESEARCHES.

Dielectric Properties of Resins.

It was mentioned in the last Annual Report (*vide I. L. R. I. Annual Report,*

1944, p. 6) that to obtain comparable results with lac and its constituents dielectric measurements had been undertaken for some other natural resins, especially those which are usually employed in the electrical industry. A brief mention was made there about the rotating units of dammar and mastic resin in the alternating current field to the effect that they were bigger than those of lac, the values of radii as calculated from Stoke's law, being only 4.5 A. U. and 2.7 A. U. respectively for mastic and dammar. Subsequently a confirmation of the respective order of dimensions was also obtained from a dielectric dispersion study of their solutions in non-polar solvents. Two papers entitled 'The dielectric properties of dammar and mastic resins' and 'The dielectric dispersion of some natural resins in non-polar solvents' have been published during the year under review giving details of measurement, calculation, conclusion, etc.

Next to dammar and mastic, copal resins were chosen for similar study in view of their importance in electrical industry. These resins, however, comprise so many commercial varieties and they differ so much in their chemical and physical properties that it should be considered inadvisable to take any one of them as a representative sample. A genuine sample of hard Manilla copal was however chosen for the study of its dielectric properties in order to see in what way it differs from lac.

It has been found that the peaks of power factor and dielectric loss curves at a constant frequency reach values of about 0.075 and 0.275 respectively, thus showing a similarity of this resin to dammar in this respect. Lac curves show much higher values. A clear evidence of a 'transformation point' at 105-106°C has also been obtained from viscosity as well as d. c. conductivity data.

The effect of distribution in the relaxation time of copal rotator has been noticed and the actual loss-maximum is about one third of the calculated theoretical value for molecules having single relaxation time. The value of the distribution parameter is 0.48 calculated according to Fuoss and Kirkwood. The radius of the rotator has also been calculated as before using Stoke's law and it is only 3.8 A. U. It therefore stands midway between dammar and mastic in size. A draft paper has been prepared on 'The dielectric properties of Manilla Copal' for publication.

Insulating Properties of some Lac Varnishes.

Various insulating varnishes (baking and air-drying) have been prepared from time to time at this Intitute using lac as the main ingredient. A comparative study of their insulating properties was undertaken during the year under report. Mainly three tests were performed on each sample of varnish, *viz.*, dielectric strength tests at room temperature, at high humidity and at high temperature. The high temperature test was performed at 90°C, whilst the high himidity test was made at room temperature after conditioning the sample at a relative humidity of more than 95% for 48 hours. One mil thick tissue paper was employed for all the tests.

The following varnishes have been tested so far, *viz.*, (1) simple lac-spirit varnish (2) lac-red lead-linseed oil varnish (3) shellac-urea-formaldehyde varnish (4) shellac-urea-formaldehyde-linseed oil fatty acids varnish (5) shellac-glycerine-linseed oil varnish (6) shellac-glycerine-linseed oil-tung oil varnish (7) shellac-cashew-shell oil vernish. Some of the constituents of these varnishes as well as their percentage compositions were altered to see the effect of such a change on the insulating properties.

It appears from the results that shellac-urea-formaldehyde-linseed oil fatty acids varnish as well as shellac-cashew-shell oil varnish have very good insulating properties

among the baking varnishes. Their dielectric strength is about 1500-1900 volts/mil at the room temperature and they can withstand high temperature as well as high humidity admirably well. The details of these tests will be incorporated in a separate communication.

5. IMPROVEMENTS IN THE MANUFACTURE OF SEEDLAC, SHELLAC ETC.

Dewaxing of seedlac.

(i) Samples of seedlac, dewaxed and half-bleached by the wet process as reported last year, were prepared and periodically examined as regards their ageing and other properties. Results obtained with 11 month old samples testify to their generally satisfactory character, and suitability for application in oil-cloth and other varnishes.

The wax which is recovered to the extent of about 2.1% is of a creamy colour, and has the softening and melting points of 72-73°C and 79-80°C respectively.

(ii) Dewaxed seedlac, as made by the wet or dry method described in the last annual report, suffers from the defect that though the methods ensure more or less complete removal of wax, the resin obtained is in a fine powdery form and therefore not readily acceptable to the trade. Besides, the usual solvent process involves heating the solution to a high temperature, and the lac has to be precipitated by acid in the alkali process. Both these operations are known to affect the quality of the resulting lac adversely. So it was desired to find a process which would involve neither grinding nor heating at a high temperature. For this purpose, several solvents, particularly carbon tetrachloride, petroleum ether, turpentine and kerosene, which selectively dissolve the wax, leaving out the resin intact, were tried and finally choice was fixed upon kerosene, considering the fact that its comparatively low solvent action is more than compensated by its cheapness, availability and low volatility. The method is simple and does not require complicated equipment as will be seen from the following description :—

Two gallons of kerosene were heated in a steam-jacketed pan up to 60°C; 20 lbs. of seedlac were then added to the warm solvent when the temperature came down to 48-50°C. Heating with constant stirring was continued for one hour so as to maintain the temperature at 48-50°C. The seedlac was then filtered through in a muslin cloth bag. On the following day the wax which had separated out from the filtrate was collected on a Buchner funnel. The moist wax weighed one pound and could be used as such for making shoe polish. Its dry weight was 150 gms. i e. about 1/3 pound which means nearly 1.6% recovery of wax. In laboratory processes however it has been found possible to remove wax up to 2%. The loss of kerosene was 0.3 gallon per 20 pounds of seedlac. The seedlac can be directly processed to shellac as the adhering kerosene evaporates during melting and stretching. However, if necessary, the seedlac can be freed from kerosene by washing with 3% soda solution. Life under heat and fluidity of the final product are found to be little affected by the process. In a typical sample, they were respectively 41 minutes and 224 secs. as against 45 minutes and 190 secs. for the untreated sample. The investigation is awaiting publication.

6. INSTANTANEOUS SOUND-RECORDING DISCS.

Work had to be virtually suspended as the recording machine which was sent out

for repairs early in November 1943, has not yet been received back at the time of compiling the report. However, the process of applying the one-coat composition by spinning has been perfected and the samples have been approved as usable by the Gramophone Co. Ltd. Dum Dum. Production on card-boards has not been successful so far.

'AD HOC' INVESTIGATIONS.

1. **Battery-box manufacture**—A firm in Calcutta wanted to have a lac plastic composition to make battery boxes. Woodflour-filled composition was affected by sulphuric acid of the strength generally used in batteries, but one made up of 25% lac and 75% slate dust stood the acid. The material, however, is of lower mechanical strength and greater density than ebonite.

2. On an enquiry from a railway workshop for a bakelite varnish substitute for impregnating armature coils, a few modified shellac varnishes were tried. Although fairly satisfactory results are obtained with these, there is need for several coats of varnish and a longer processing schedule than when using bakelite. Further work is in progress.

3. A glazing varnish for finishing litho-prints was made and sent to an enquirer at Nagpur.

4. Insulating varnishes were made and sent to several enquirers. Several gallons of adhesive tape varnish were sent to a Saharanpur firm for machine trials.

5. A sample of the adhesive for bonding leather washers which could stand a pressure of 400-600 lbs. per sq. in. was made and supplied to a military artillery unit.

6. As a result of several enquiries, compositions suitable for topping corks, developed earlier, have been further m odified and improved with some added materials, such as fillers, lubricants, etc. with a view to obtaining low-melting but hard-setting compounds. About 10 lbs. of hydrolysed lac was sent to a firm in South India for making such a composition.

METEOROLOGICAL REPORT.

The monthly averages of meteorological data during the year are given below :—

Month		Max. temp. °F	Min. temp. °F	Relative humidity. %	Sunshine (hours per day)	Wind speed (miles per hour)	Rainfall (inches)
April	1944 . .	93·5	65·2	41	9·2	3·3	0·95
May	„ . .	106·1	77·3	32	9·9	2·7	1·45
June	„ . .	98·1	75·2	56	7·2	2·5	7·03
July	„ . .	86·3	73·7	80	4·1	3·6	19·76
August	„ . .	85·4	72·9	83	4·0	3·8	21·0
September	„ . .	91·1	72·2	70	5·3	1·7	6·22
October	„ . .	85·1	63·5	73	5·8	2 5	6·11
November	„ . .	81·3	51·7	48	9·0	1·0	0·08
December	„ . .	78·9	47·6	50	9·1	1·3	. .
January	1945 . .	73·1	45·6	59	7·7	1·7	2·37
Februry	„ . .	76·7	47·4	42	10·5	2·1	1·50
March	„ . .	88·9	59·8	34	10·3	2·0	. .

GENERAL APPENDIX I

Tabulated statement of the progress of investigations

Item	Commenced in	Progress in 1944-45	Future work proposed.
1. **Moulding Powders** (a) Shellac formaldehyde urea	1938–39.	(1) Work on saw-dust from different Indian woods as a filler after washing, grinding, alkali treatment etc. has been partly completed.	To be continued.
		(2) Improving flow and gloss: partly completed.	To be continued.
		(3) Incorporation of cashew shell oil with a view to improve the water-resistance and flow.	To be continued.
(b) Injection Moulding	1939–40.	Compositions with different fillers examined	To be continued.
2. **Varnishes and Lacquers**	1941–42.	(1) Artificial leather, oil-cloth and bookbinder's cloth have been prepared successfully both in the laboratory and on the factory scale. Stiffening of the fabric has been overcome by the use of castor oil fatty acid and other nondrying oil acids.	To be continued.
		(2) A lac-oil vornish: A new composition and a new process have proved satisfactory for making oil-cloth, insulating fabric (empire cloth).	To be tested and compared with earlier compositions.
		(3) Improved shellac-spirit varnishes for electrical insulation by using cashew shell oil. Work partly completed.	To be continued for testing various film properties.
3. **Adhesives**	1937–38.	Development of lac adhesives suitable for joining glass to glass, glass to metal, metal to metal etc.	To be continued for determining adhesive quality on other surfaces, e. g. moulded parts to each other, metal to moulded parts etc.
4. **Fundamental Researches:** (i) Electrical properties	1940–41	Dielectric properties of lac and other natural resins studied. Electrical properties of lac-spirit and lac-oil varnishes.	To be continued along same lines.
5. **Recording discs:**	1941	(1) Paper-boards and laminated boards have been used instead of aluminium boards.	To be continued along same lines.
		(2) Method of coating has been improved. (3) Improved compositions have been tried.	Improvements in the film properties with respect to surfaces, cutting quality etc. Experiments on the use of laminated paper boards as base to be continued.
6. (a) Improvents in the Manufacture of seedlac, shellac, etc.	1943	(1) Improvment in the bleaching of lac. Bleached lac obtained by improved process and stored for testing at regular intervals. (2) Investigations on partial dewaxing of lac and preparation of light coloured lacs have been completed.	
(b) Technical separation of lac-wax	1944	By extraction with cheap solvents.	Nil.
7. **'Ad hoc' researches**		(i) Sealing compositions for cork-tops (ii) Insulating varnishes for radio parts, motor coils, empire cloth, etc. (iii) Adhesive tape compositions. (iv) Baking enamel for cycle parts. (v) Varnish for stiffened fabrics. (vii) Battery-box compositions. (viii) Glazing varnish for finishing litho paints.	Nil.

GENERAL APPENDIX II

*Total sticklac production in India (in maunds) **

Year	*Baisakhi*	*Jethwi*	*Katki*	*Kusmi*	*Total*
1944—45	770,500	12,500	**135,000	39,750	**975,750
1943—44	372,000	67,000	224,250	185,750	849,000
1942—43	1,038,250	102,500	151,250	81,750	1,373,750

* From the Crop-Statistician's figures.

** Excludes the estimated Katki-crop of Assam.

GENERAL APPENDIX III

List of Publications during 1944—45.

1. *Bulletin No. 55*—Dielectric properties of lac, by G. N. Bhattacharya.
2. *Bulletin No 58*—Dielectric properties of constituents of lac, by G. N. Bhattacharya.
3. *Bulletin No. 59*—Dielectric properties of different mixtures of hard and soft lac resins, by G. N. Bhattacharya.
4. *Bulletin No. 60*—Dielectric properties of modified lac, by G. N. Bhattacharya.
5. *Bulletin No. 61*—Dielectric properties of dammar and mastic resins, by G. N. Bhattacharya.
6. *Bulletin No. 62*—Dielectric dispersion of a few natural resins in non-polar solvents, by G. N. Bhattacharya.

IN THE PRESS

1. Study on the constitution of soft lac resin, by T Bhowmik and H K. Sen.
2. The manufacture of lac-wax and partially dewaxed shellac by alkali process, by S. C. De.
3. Industrial applications of plasticised lac, by Y. Sankaranarayanan.
4. Shellac as an ingredient of rubber compositions, by Dr. J. R. Scott (British Rubber Manufacturers Research Association, Croyden.)
5. Relative importance and practicability of various methods of control against insect predators and parasites of the lac insect, by P. S. Negi, S. N. Gupta, M. P. Misra, T. V. Venkatraman and R. K. De.
6. Preliminary note on Biological Control of *Eublemma amabilis* Moore, a predator of lac insects by one of its indigenous parasites, *Microbracon greeni*, Cam., by P. S. Negi, S. N. Gupta, M. P. Misra, T. V. Venkatraman and R. K. De.

GENERAL APPENDIX IV

List of Patents filed and/or sealed in 1944—45

1. New varnish for flexible and waterproof coatings **No. 29894 (Sealed)**

2. Shellac Adhesives for bonding Plywood. **No. 31828 (filed)**

ENTOMOLOGICAL SECTION.

1. Improving crop production on Palas (*Butea frondosa*) by artificial partial defoliation in the Kundri Forest Area.

On ehundred trees in coupe V were artificially defoliated to the extent of $\frac{7}{8}$ ths of their leaves 2 days before infection as against 23 days of the previous year and 100 trees in coupe IV were infected without defoliation to serve as control. 1 maund 33 seers of brood lac were required to infect the defoliated coupe V as against 2 maunds 31 seers to infect the control coupe IV. The partial defoliation thus resulted in this particular instance in an economy of brood lac to the extent of 38 seers. The cost of defoliation was Rs. 2-12-0 and the cost of the brood saved on account of defoliation was Rs. 47/- approx. at the rate of Rs. 47/- a maund.

As practised by the villagers a part of the crop was cut immature (*ari*) in the third week of April from the control coupe but not from the experimental one.

By the 19th April 1944, 19 control and 58 experimental trees had begun to put forth new leaves. Climatic conditions remained very favourable till the end of April 1944 and no mortality occurred in the lac insects owing to heat either in the control or in the experimental trees, but in May and practically till the end of June there was a continuous spell of heat and drought which caused heavy mortality among the lac insects. The crop on the control as well as on the experimental trees was, therefore, left for self-infection and harvested in October on maturity of the resulting *Katki* crop. The amount of brood lac obtained from the control and experimental trees is given in table I.

TABLE I.

Brood lac obtained.

Crop	Control (100 trees)	Experimental (100 trees)	Ratio of control brood to experimental
Baisakhi	½ lb.	22 lbs.	1:44
Self-infection Katki	2½ lbs. Partly developed insects.	73 lbs. Well developed insects.	1:29·2
	Total yields of scraped lac from control and experimental trees have not been compared as driage in *ari* and mature scraped lac varies greatly and experience has shown that the problem of driage in scraped lacs should be studied separately.		

2. Determination of most suitable pruning methods and seasons for Kusum, Ber and Palas.

Due to continuous unfavourable climatic conditions during the larval emergence

in January-February 1944, the *Jethwi* 1944 crop was practically a complete failure in all the localities, with the result that no kusum brood lac was available in June for the infection of the *Aghani* crop, and the experiment could not be restarted. However, the results of the unsuccessful *Jethwi* crop confirm the finding of the previous year, namely, that the ratio of brood to yield for trees having six-month old shoots was almost as good as that for the trees bearing 1½ year-old shoots.

Z. Jujuba (Ber)—Trees pruned in the first halves of February and April yield better crops than those pruned in the second half of the same months, but as the crop-cutting times vary from year to year by a week or so and the *Baisakhi* crop is mostly cut *Ari* (immature) in the 4th week of April, it may be laid down as a sort of general rule that Ber should be pruned in February to grow the *Katki* crop, and in April to grow the *Baisakhi* crop, pruning being done wherever possible, preferably in the first half of these months. The brood to yield ratio of the *Ari Baisakhi* crop which is liable to considerable driage varied from 1:6·0 to 8·5 and of the *Katki* crop 1:3·9 to 10·7 depending on the size and condition of trees.

B. frondosa (Palas)—The pruning of Palas owing to scarcity of labour and other reasons had to be prolonged over a month in each season and therefore the correct pruning times have not yet been determined.

3. Investigating the economics of utilizing Palas for the Baisakhi crop only and Ber for the Katki crop only in areas containing both hosts.

The *Baisakhi* 1943-44 crop on Palas as well as on Ber suffered heavily from continuous drought and heat. From 582 Ber trees which had not received any special treatment no brood lac was obtained, while from 206 Palas trees which also did not receive any special treatment 1 maund 34 seers 8 chattacks of brood lac could be obtained. The data show the superiority of Palas to Ber as a *Baisakhi* host.

4. Mortality and Fertility in lac insects.

Crop.	Strain.	Mortality % Average.	Mortality % Total.	Actual fecundity.
Baisakhi 1943-44—	Ber × Ber	45·2	86·3	257·2
	Palas × Palas, Control	54·2	67·2	222·6
	Palas × Palas, Exptl.	55·8	67·2	253·9
Jethwi 1944—	Kusum × Kusum (Hosel)	70·9	79·5	crop failed
	Kusum × Kusum (Berwari)	68·1	70·4	" "
Katki 1944—	Palas × Palas, Control	67·9	76·6	215·6
	Palas × Palas, Exptl.	68·4	72·4	230·7
	Ber × Ber	62·3	74·8	231 8
	Ber × Palas	61·3	75·0	219·4
	Palas × Khair	64·9	84·2	250·4
	Palas × Ber	69·4	75·1	228·4
* *Aghani 1944-1945*—	Kusum control	67·9	72·4	crop failed
	Kusum exptl.	75·8	77·1	" "

Due to continuous heat during May and June the fertility in the *Baisakhi* as well as in the resulting *Katki* crops were lower than in the previous year. The *Jethwi* and *Aghani* crops failed owing to unfavourable climatic condition (rain and cold) at the time of infection of the *Jethwi* crop.

5. BIONOMICS AND LIFE HISTORY OF M. GREENI UNDER CONTROLLED HUMIDITY AND TEMPERATURE.

As in the last year the experiments were conducted with two improvised incubators constructed locally. The host offered mainly was *E. amabilis* larva but towards the later part of the year *Pongamia* borer was also offered. The results are given below, and unless mentioned otherwise the host offered should be taken as *E. amabilis* :—

Month.	Conditions of breeding.	Host larvae.		Percentage parasitisation.	Adults bred per host.	Percentage of females bred.
		Introduced.	Parasitised.			
April	Laboratory :— Temp. 68° to 90°F R. Humidity 29 to 72%	62	20	32·2	0·5	80·0
	Controlled :— Temp. 77° to 89°F R. Humidity 50 to 80%	55	19	34·6	—	73·3
May	Laboratory :— Temp. 81° to 100°F R. Humidity 22 to 57%	40	16	40·0	0 8	91·6
	Controlled :— Temp. 77° to 87°F R. Humidity 50 to 80%	25	10	44·0	1·6	82·4
June	Field work interrupted breeding.					
July	Laboratory :— Temp. 74° to 87°F R. Humidity 72 to 87%	15	4	26·6	0·8	66·7
	Controlled :— Temp. 78·8° to 80.6°F R. Humidity 80 to 82%	10	3	30·0	1·0	100·0
Aug.	Laboratory :— Temp. 74° to 83°F R. Humidity 72 to 91%	30	8	26·7	0 75	66·7
	Controlled :— Temp. 77° to 82°F R. Humidity 81 to 85%	25	6	24·0	1·3	62·5
Sept.	Laboratory :— Temp. 78° to 87°F R. Humidity 62 to 80%	20	7	35·0	0·6	75·0
	Controlled :— Temp. 78·8° to 84·2°F R. Humidity 81 to 85%	20	7	35·0	0·7	60·0
Oct.	Field work interrupted breeding.					
Nov.	Laboratory :— Temp. 66° to 76°F R. Humidity 59 to 95%	90	38	42·2	1·8	86·3
	Controlled :— Temp. 68° to 79°F R, Humidity 68 to 78%	70	37	52·8	1·5	100·0

Month.	Conditions of breeding	Host Larvae.		Parcentage parasitisation	Adults bred per host	Percentage of females bred
		Introduced	Parasitised			
Dec.	Laboratory :— Temp. 64° to 74°F R. Humidity 60 to 95% Controlled :— Temp. 70° to 81°F R. Humidity 68 to 70%	10 15	4 4	40·3 26·6	1·8 1·2	84·4 83·3
Jan.	Laboratory :— Temp. 58° to 70°F	27	1	3 7	1	100 0
	R. Humidity 21 to 100% Pongamia borer	81	nil	nil	nil	nil
	Controlled :— Temp. 64° to 78°F	67	4	5 9	2·0	62·5
	R. Humidity 50 to 76% Pongamia borer	120	nil	nil	nil	nil
Feb.	Laboratory :— Temp. 60° to 76°F Pongamia borer R. humidity 40 to 95% Controlled :— Temp. 56° to 74°F R. humidity 45 to 75% Pongamia borer	39 27	7 nil	17·9 nil	1·2 nil	33·3 nil
March	Laboratory :— Temp. 70° to 90° F Pongamia borer R. humidity 45 to 78% Controlled : Temp. 72° to 88°F R. humidity 50 to 60% Pongamia borer	24 54	nil nil	nil nil	nil nil	nil nil

The data on the whole support the results obtained in the previous year, namely, that the temperature within a certain range is more important for the development and biology of the braconid than humidity. The percentage of parasitism under both laboratory and controlled conditions was rather low.

6. Mass Breeding of M. greeni in the laboratory.

(i) *Breeding or collection of the natural host E. amabilis,, and of suitable alternative hosts in the laboratory.*

E. amabilis was bred in the laboratory as well as collected from the field, and

the alternative hosts were more often collected than bred. From January 1945 mainly the alternative hosts are being tried. The hosts used are as follows :—

E. Amabilis & alternate hosts bred or collected.	No. of larvae made available for parasitisation.
E. amabilis	22,073
Platyedra gossypiella (cotton boll-worm)	67
Leucinodes orbonalis (brinjal borer)	29
Scirpophaga nivella (Sugarcane borer)	23
Emmalocera depressella (Sugarcane borer)	17
Seed borer of Pongamia glabra	4,629
Cataglyphis bicolor (ant)	960
Borer of Amaltas (*Cassia fistula*) pods	61

(ii) *Breeding of M. greeni*

Breeding was greatly handicapped during summer and winter due to unfavourable condition and want of suitable equipment to control temperature and humidity. Data for those hosts only on which breeding was successful are given below :—

Host & No. of larvae introduced	No. parasitised	Parasitism %	*M. greeni bred.*		% of females	Adult bred per host
			Males	Females		
E. amabilis 21,407	10,919	51.0	1,646	7,423	81.8	0.83
P. gossypiella 67	2	3.0	1	2	66.6	1.5
L. orbonalis 29	6	20.9	1	2	66.6	0 5
S. nivella 22	12	54.5	4	8	66.7	1.0
Seed borer of *Pongamia glabra* 2,248	1,109	49.3	81	199	71.1	0.3
C. bicolor 960	264	28.1	19	29	60.4	0.17
Borer of Amaltas (*Cassia fistula*) pods 61	7	11.5	nil	2	100	0.28

The number of *E. amabilis* larvae offered for breeding is less than last year for two reasons : (1) the failure of the last two *Kusumi* crops restricted the source of supply of *Eublemma* to *Rangeeni* crops only, (2) from January 1945 attention is mainly being paid to discovery of suitable unnatural hosts for breeding *M. greeni* in the laboratory.

(iii) *Host selection* :—With a view to find out suitable alternative hosts to breed *M. greeni* in the laboratory further tests were carried out with the help of an olfactometer to determine the nature of oviposition response of the parasites produced to such stimuli as size, texture and odour of the host. Preliminary trials indicate that odour emanating from the host larva and the dome-shaped covering associated with it are dominant factors in the initial attraction of the parasite to the host from a certain distance. The olfactory sense appears to reside in the basal segments of the antennae. Adults devoid of antennae or adults having antennae coated with shellac varnish appear to evince little interest to oviposition.

7. RELEASES OF MICROBRACON GREENI AND EXAMINATION OF KUSUMI CROPS IN HESAL AND BERWARI AND OF PALAS IN BARGUTTU.

The experiments were continued on *Kusumi* crops on *Kusum* (*S. trijuga*) in Hesal and Berwari and on Rangeeni crops on Palas (*B. frondosa*) in

Barguttu. Both the kusumi crops (*Jethwi* and *Aghani*) were unsuccessful, unfavourable climatic conditions having almost completely destroyed the *Jethwi* crop, and the consequent paucity of brood lac having resulted in the failure of the *Aghni* crop; however, the expriments were conducted as best as possible and the data colleced

Once a week the braconids were released in two areas i. e. in Hesal and in the experimental coupe in Barguttu, and samples collected for examination from Hesal, Berwari and Barguttu experimental as well as control coupes. The objective of the experiment was to find the difference between the population of *E. amabilis* during the period of one and the same crop in the experimental and control areas due to introduction of an additional parasitisation by *M. greeni* in the experimental areas.

Without resorting to statistical interpretation of data on which opinions are likely to differ, the data tabulated below for the four crops clearly confirm the statements made in the previous reports that *M. greeni* releases were effective in controlling *E. amabilis*. In three out of four crops the density of *E. amabilis* was less in the experimental than in the control area, and in all the four crops the percentage parasitisation was over 100% more in the experimental than in the control area. The *Jethwi* 1944 crop in which the density of *E. amabilis* was more in the experimental area than in the control is the direct progeny of *Aghani* 1943-44 crop in which large number of *E. amabilis* moths emerged from the stored phunki (swarmed out-brood) and dispersed in the experimental area and resulted in the increase of the predator population.

(A) Baisakhi crop 1943-44 (October to June)

10,581″ of lac sticks were examined from the control and 10,490″ from the experimental coupe of Burguttu.

(*a*) *M. greeni released* :—Males. 3,944 Females. 11,378

(*b*) *Population density of E. amabilis and parasitism percentage by M. greeni per 100″ in Barguttu.*

Month & week.	Trees examined	Parasitisable stages of *E. amabilis*.			Parasitism percentage by *M. greeni*.		
		Control.	Exptl.	Difference.	Control.	Exptl.	Difference.
Feb. 1st. week— Initial exam.	27	0·2	0·7	—0·5	Nil	Nil	Nil
Feb. 2nd week	9	1·1	1·7	—0·6	37·5	Nil	37·5
„ 3rd „	9	1·1	0·7	—0·4	33·3	Nil	33·3
„ 4th „	9	Nil	0·5	—0·5	Nil	Nil	Nil
March 1st „	9	1·1	Nil	+1·1	Nil	Nil	Nil
„ 2nd „	9	Nil	0·5	—0·5	50·0	Nil	50·0
„ 3rd „	9	0·5	1·0	—0·5	Nil	Nil	Nil
„ 4th „	9	1·3	0·7	+0·6	33·3	33·3	Nil
„ 5th „	9	0·7	0·5	+0·2	Nil	Nil	Nil
April 1st „	9	0·9	0·5	+0·4	100·0	Nil	100·0
„ 2nd „	9	0·9	0·5	+0·4	100·0	25·0	75·0
„ 3rd „	9	0·9	0·2	+0·7	Nil	Nil	Nil
„ 4th „	9	0·5	Nil	+0·5	Nil	Nil	Nil

Month & week.	Trees examined.	Parasitisable stages of *E. amabilis*.			Parasitism percentage by *M. greeni*		
		Control.	Exptl.	Difference.	Control	Expti.	Difference.
May 1st „	9	1·4	0·9	+0·5	50·0	Nil	50·0
„ 2nd „	9	0·9	0·7	+0·2	33·3	Nil	33·3
„ 3rd „	9	1·0	0·5	+0·5	50·0	Nil	50·0
„ 4th „	9	0·2	0·4	—0·2	100·0	Nil	100·0
June 1st „	9	0·2	0·2	Nil	100·0	Nil	100·0
„ 2nd „	9	0·9	0·9	Nil	25·0	50·0	—25·0
„ 3rd „	27	1·2	1·0	+0·2	53·8	18·8	35·0
Final examination							
Average mean	...	0·7	0·6	+0·1	40·0	11·4	28·6

(B) Katki 1944 (June to October)

4,953″ of lac sticks were examined from the control and 4,909″ from the experimental coupe of Barguttu.

(a) *M. greeni released* :—Males. 7,304 Females 6,966

(b) Population density of *E. amabilis* and percentage parasitisation by *M. greeni* per 100″ in Barguttu.

Month & week.	Trees examined.	Parasitisable stages of *E. amabilis*			Parasitism percentage by *M. greeni*.		
		Control.	Exptl.	Difference	Control.	Exptl.	Difference.
Aug. 5th week— Initial exam.	27	2·4	1·6	+1·2	Nil	Nil	Nil
Sept. 1st week	9	5·2	4·0	+1·2	4·5	22·2	—17·7
„ 2nd „	9	1·4	3·0	—1·6	16·6	15·5	1·1
„ 3rd „	9	4·7	0·9	+3·8	13·6	Nil	13·6
„ 4th „	9	2·0	1·8	+0·2	22·2	37·5	—15·3
„ 5th „	9	0·9	2·5	—1·6	Nil	36·4	—36·4
Oct. 1st week Final exam.	27	6·3	3·5	+2·8	10·2	36·4	—26·2
Average mean		3·7	2·5	+1·2	8·7	18·8	—10·1

(C) Jethwi 1944 (January to June)

6,288″ of lac sticks were examined from the control (Berwari) and 6,901″ from the experimental (Hesal).

(a) *M. greeni released* :— Males 1,128 Females 2,908

(b) Population density of *E. amabilis* and percentage parasitisation by *M. greeni*.

Month & week.	Trees examined.	Parasitisable stages of *E. amabilis*.			Parasitism percentage by *M. greeni*		
		Control.	Exptl.	Difference.	Control.	Exptl.	Difference.
April 1st week Initial examination.	27	Nil	0·5	—0·5	Nil	Nil	Nil
April 2nd week	9	0·4	2·2	+1·8	Nil	10·0	—10·0
„ 3rd „	9	0·2	1·0	+0·8	Nil	40·0	—40·0
„ 4th „	9	1·8	2·1	—0·3	Nil	60·0	—60·0
May 1st „	9	0·4	1·7	—1·3	50·0	Nil	50.0
„ 2nd „	9	Nil	1·4	—1·4	Nil	42·8	—42·8
„ 3rd „	9	0·9	3·9	—3·0	Nil	29·4	—29·4
„ 4th „	9	0·3	1·7	—1·4	Nil	42·8	—42·8
„ 5th „	9	0·2	3·3	—3·1	Nil	6·7	—6·7
June 1st „	9	1·5	2·4	—0·9	Nil	20·0	—20·0
„ 2nd „	9	1·3	4·0	—2·7	25 0	52·9	—27·9
„ 3rd „ Final examination.	27	1·7	6·6	—4·9	40·7	60·8	14·1
Average mean		0·7	2·8	—2·1	20·9	41·7	—20·8

(D) Aghani 1944-45 (June to January)

As the *Jethwi* crop had practically failed, it was left on the trees for self-infection and the resulting *Aghani* crop was examined twice a month from October to December. All the lac-bearing twigs were cut from each tree and examined. 781″ of lac sticks were examined from control (Berwari) and 249·5″ from the experimental (Hesal).

(a) *M. greeni released* :—

Males.	Females.
11,439	10,770

(b) Population density of *E. amabilis* and percentage parasitisation by *M. greeni* per 100″.

Month & week.	Trees examined.	Parasitisable stages of *E. amabilis*.			Parasitism percentage. by *M. greeni*		
		Control.	Exptl.	Difference.	Control.	Exptl.	Difference.
Oct. 1st week	Control 4	56·4	38·4	17·5	4·1	15·3	—11·2
Intitial examination.	Exptl. 10	—	—	—	—	—	—
Nov. 1st week	2	16·8	25·5	—8·7	Nil	Nil	Nil
„ 3rd „	7	7·7	17·1	—9·4	15·8	13·8	2·8
Dec. 1st „	2	51·7	11·7	40·0	6·6	41·1	—34·5
„ 3rd „	Control 5	—	—	—	—	—	—
Final examination	Exptl. 6	36·5	20·0	16·2	9·0	24·2	—15·2
Average mean		28·2	25·3	2·9	8·7	19·6	—10·9

In the four crops in two areas detailed above 55, 837 *M. greeni* were released against 43, 158 of the previous year.

CROP STATISTICS.

Crop & Locality.	Brood used		Crop yield		Brood and yield ratio	
	Wt. of lac sticks	Wt. of scraped lac	Wt. of lac sticks	Wt. of scraped lac	Of lac sticks	Of scraped lac.
	Md. Sr Ch.	Md. Sr. Ch.	Md. Sr. Ch.	Md. Sr. Ch.		
Baisakhi 1943-44.						
Barguttu control	50–21 –8	7–21–12	122– 9– 0	22–39– 4	1:2.4	1:3.1
Barguttu Exptl.	45–28 –0	7–33–12	131– 9– 0	23–27– 8	1:2.87	1:3.02
Hesal	2–15 –0	0–16– 0	22–24–12	5– 1– 4	1:9.5	1:12.56
Berwari	6–19– 0	0–38– 8	47–10– 0	12–21– 8	1:7.3	1:13.2
Katki 1944.						
Barguttu control	70–14– 0	16–15– 4	70–34– 8	3–20– 8	1:1.0	1:0.23
Barguttu Exptl.	53–25–12	11– 1– 0	86–18– 0	6– 7– 8	1:1.5	1:0.56
Hesal	0–28– 0	0– 7– 4	6– 8– 0	0–23–12	1:8,9	1:3.04
Berwari	10– 6– 8	2–25– 8	71– 2– 4	8– 2– 8	1:7.0	1:3.06

N. B.:—Statistics for the *Kusumi* crops (*Jethwi* and *Aghani*) are not given as the *Jethwi* crop had failed and the *Aghani* crop could not be infected due to paucity of brood lac.

8. ARTIFICIAL CONTROL OF INSECT ENEMIES BY HEAT TREATMENT.

As in the previous year, large-scale trials with lac sticks were carried out in different seasons in a closed room heated by *Angithis* to different ranges of temperature. 2 lbs. of sticklac was caged for the emergence of insects from each treated lot and its control, and the rest was sent to the lac factory for conversion into shellac and its analysis; the results are briefly summarised below:—

EMERGENCE OF INSECTS AND EFFECT OF TREATMENT.

Particulars of Treatment	Predators*		Parasites & other insects	Total
Jan. '44 control	52	*Eublemma*		
	96	*Holcocera*	22	170
Jan. '44 heat-treated	26	*Eublemma*		
48.9°–54.1°C for 4 hours	76	*Holcocera*	15	117
July '44 control	89	*Eublemma*		
	132	*Holcocera*	132	353
July heat-treated	38	*Eublemma*		
52.2°–62.2°C for 6 hours	150	*Holcocera*	77	265
Dec. '44 control	8	*Holcocera*	1518	1526
Dec. '44 heat-treated				
38°–56°C for 8 hours	7	*Holcocera*	919	926

*For the two predators (*Eublemma* and *Holcocera*) results should be judged from the emergence of *Eublemma* and not of *Holcocera* as the latter continues to breed in stored and dry lac also.

The experiments indicate a higher minimum temperature than 52°0 and a longer exposure than 6 hours for optimum results. The chemical analysis shows practically no difference between shellac obtained from the heat-treated and the control lac.

9. DEMONSTRATION OF IMPROVED METHODS OF CULTIVATION AND ADVICE TO CULTIVATORS ON REQUEST; IMPROVED CULTIVATION IN FOREST AREAS IN CO-OPERATION WITH THE FOREST DEPARTMENT.

(A) (i) *DEMONSTRATION.*

Cultivators were told to observe the following and actual demonstrations were given on their tress. (1) Advantages of cultivation by coupe system, (2) preservation of *Baisakhi* crop on *Ber* by partial pruning, (3) in localities where the same owner owns Palas and Ber trees he was asked to cultivate Palas for the *Baisakhi* crop and Ber for the *Katki* crop only, (4) increased and improved cultivation on Kusum.

Baisakhi 1943-44 crop:—

Ber:—In Palamau some trees were kept as control and divided into two groups to correspond with the two experimental groups mentioned hereafter, and the rest were divided into two experimental groups, one of which was partially pruned before infection in October and the other two months after infection. The results are summarized below:—

Out of 582 control trees of both the groups lac had to be cut *Ari* in April-May from 527 trees because all the lac insects had died on them, and the remaining 55 trees were cropped at crop maturity in June but no brood lac was obtained from them; whereas from 250 partially pruned trees of both the groups 1 maund 20 seers of brood lac was obtained. It has been stated before that the heat and drought in May and June were continuous and severe. The data offered above clearly demonstrate that partial pruning greatly helps in preserving the brood lac. The amount of brood lac obtained from trees partially pruned before and after infection was almost equal.

Palas:—129 trees were infected after partial defoliation in Palamau and 206 trees without defoliation in Mirzapore district, at crop maturity the former produced 2 maunds 31 seers and 8 chattaks of brood lac and the latter 1 maund 34 seers and 8 chattaks. The results obtaind illustrate two facts: (1) From brood lac point of view Palas is better suited than Ber to grow the *Baisakhi* crop, (2) partial defoliation helps in conserving more brood lac on Palas in the *Baisakhi* crop than otherwise.

Katki 1944 crop.

In all the lac growing areas the *Katki* crop was poor but in the Institute demonstration areas it was fairly satisfactory. The brood and crop yield ratio was 1:2.7-3.0.

In Bengal, among the cultivators the prevailing belief is that the progeny of brood lac from Bihar which emerges later than that of their own province or its adjacent areas of Bihar does not thrive in Bengal. To convince the cultivators of the incorrectnes of their belief, two centres, one in Malda and another in Murshidabad, were selected. Local as well as Ranchi brood lac were used for infection in both the centres. To avoid

infestation by parasites and predators from the early emerging local brood lac, Ranchi brood lac was used to infect the trees isolated from those infected with local brood lac. The results given below clearly show that Bihar brood lac can be suecessfully propagated in Bengal provided that it is not used in the neighbourhood of the trees infected with local brood.

Centre.	Brood lac infected.	Brood lac obtained from resulting crop.	Remarks.
	Md. Sr. Ch.	Md. Sr. Ch.	
Murshidabad	1—0—0 Ranchi.	1—0—0	Crop from 4 trees was stolen.
	0-34—0 Local.	0-20—0	
Malda	0-27—0 Ranchi.	1-20—0	A part of the crop was left over on trees for self-infection.
	0-30—0 Local	0-25—0	A part of the crop was left over on 10 trees for self-infection

Jethwi 1944 crop :

The *Aghani* 1943-44 crop matured in January-February and the infection for *Jethwi* 1944 crop was carried out at the same time. Due to rains and continued low temperature, the emergence of lac larvae was greatly interfered with and the larval settlement was extremely poor hence the *Jethwi* crop practically failed in all the areas except one which is hotter than Ranchi and where the Ranchi brood was used. 18 Kusum trees not only produced sufficient brood lac for their own self-infection but also yielded a surplus of 30 seers. This fact clearly supports the Institute finding that in Jan.-Feb., if the climatic conditions are adverse to swarming of lac larvae and if the larval swarming be forced out by raising the temperature, there would be less failures of *Kusumi* crops.

Aghani 1944-45 crop :

Except in the locality (Palamau) where the *Jethwi* crop was successful, no *Aghani* crop could be grown for want of brood lac. In the locality where the *Jethwi* crop was successful about 5 maunds of *Aghani* brood lac was estimated but the owner of the trees on account of his continued illness neglected the crop and could not collect it.

Distribution of broodlac and pruning instruments 1944-45.

	Demonstration campaign		Intensive demonstration		Special sanction	
	Quantity Md. Sr. Ch.	Cost. Rs. A. P.	Quantity Md. Sr. Ch.	Cost Rs. A. P.	Quantity. Md. Sr. Ch.	Cost. Rs. A. P.
Rangeeni brood lac	15-27- 8	895- 8-0	8-26- 0 in U. P. 4- 0- 0 46 Turies in Bengal)	457- 5- 0 304- 4- 0	16-20- 0 2190 Turies.	6008-6-0
Kusumi brood lac	4-10- 0	233-12- 0	0-20- 0 in U. P.	27- 8- 0		
Pruning instruments			12 in U. P. 12 in Bengal.	42- 0- 0 50- 0- 0		

(ii) *Advice to cultivators and training in lac cultivation.*

Advice on lac cultivation was given to cultivators all over India and working plans were prepared for a prominent Zamindar of Ranchi and the Forest Department, Bihar for the Kundri forest.

One Forest Officer from Baroda, two from Mysore, one from Kawardha, two from Jaipur, one from Court of Wards C. P. and two Institute Demonstrators completed their training in lac cultivation. One Forest Officer from Khairagarh, six supervisors and eight demonstrators from Bihar, five demonstrators from Bengal and one private candidate from Udaipur State are under training.

(B) Improved cultivation in forest areas.

The investigation centres continued to be the Bihar Government orchard Mako and the reserved forest Oreya. The *Jethui* 1944 crop, as expected, failed owing to unfavourable climatic conditions at the time of infection, and consequently the *Aghani* 1944-45 crop could not be grown for want of brood lac. The investigations had therefore to be confined to *Rangeeni* cropss at Mako. The *Katki* crops were grown on stunted Ber trees and Khair; and the *Baisakhi* crops were grown on Palas, Ber, Pandan *(Ouegeinia dalbergioides)* and Barh *(Ficus bengalensis)*; on the last three unlike Ber, the *Baisakhi* brood lac survived in fair quantities. The investigation has thus resulted in introducing two more possible *Baisakhi* hosts e.g., Pandan and Barh. It is the first time in the history of Mako orchard that it yielded over twenty five maunds of surplus brood lac fetching a revenue of Rs. 1,229-13-0. The scheme completed its final (third) year. The financial statement given below shows that in spite of the bad start in 1942 with poor quality *Jethwi* brood lac, failure of the last two *Kusumi* crops (*Jethwi* 1944 and *Aghani* 1944-45) and unforeseen and unprecedented rise in the cost of labour, the scheme has fared better than anticipated. The actual receipts exceeded the estimated sum by Rs. 1,414.

Financial Statement.

Year	Sanctioned budget	Actual expenditure	Expected receipts	Actual receipts
1942—43	Rs. 3,891—0—0	Rs. 3,891—1—4	Rs. 705—0—0	Rs. 742—8—9
1943—44	Rs. 1,000—0—0	Rs. 2,224—5—6	Rs. 1,732—0—0	Rs. 2,833—0—0
1944—45	Rs. 2,233—0—0	Rs. 2,841—14-0	Rs. 2,332—0—0	Rs. 1,802—0—0

10. 'AD HOC' INVESTIGATIONS.

Dates of emergence of lac larvae were forecasted at different crop maturity periods. Under special scheme brood lac was distributed in Malda and Murshidabad districts in Bengal.

Brood lac was examined, collected and sold to several Indian States and to private cultivators. Four pounds of Palas brood lac was supplied to U. S. S. R. through their Consul in Kabul. Seeds of several species of lac hosts were sown and some of the seedlings were transplanted.

Cajanus indicus (Arhar) seeds were collected and sown. *T. candida* (Bogamedallor) was sown and used as green manure.

Hollyhock, hibiscus, cotton, peas, brinjal and sugarcane were cultivated on a small scale in the Namkum plantation to breed their pests which served as alternative hosts to breed *M. greeni* in the laboratory.

11. SUBSIDIARY INVESTIGATIONS.

(i) Examination of prospects of lac cultivation on *A. lucida* and *D. lanceolaria* in Bihar by experiments at the Institute.

Both the hosts carried the *Baisakhi* crop successfully from the brood point of view. *A. lucida* gave better yield than *D. lanceolaria*. The brood and crop ratio for *A. lucida* was 1: 2. 3 and for *D. lanceolaria* 1: O. 6. However, the *A. lucida* brood did not produce a satisfactory *Katki* crop on Khair, the brood and yield ratio was 1: O. 7. only.

(ii) Asexual breeding of the female lac insect at the Institute plantation to evolve a better brood.

The eleventh generation of the strain is developing normally. The average fecundity in the ninth generation was 345·7 and in the tenth 315·6.

APPENDIX.

(ENTOMOLOGICAL SECTION)

A statement of lac produced and its disposal.

Locality.	Scraped lac produced and its disposal									Brood lac distributed free or sold			
	Produced.			Under use in Department			Driage.			Supplied to lac factory or sold			Distributed free.			Sold		
	Md.	Sr.	Ch.	Md.	Sr.	Ch.	Md.	Sr	Ch.	Md.	Sr.	Ch.	Md.	Sr.	Ch.	Md.	Sr.	Ch.
Baisakhi 1943-44.																		
Barguttu	43	21	4	—			7	27	2	35	34	2	—			13	12	0
Hesal	5	1	4	—			1	5	4	3	36	0	—			—		
Berwari	7	37	8	—			2	21	0	5	16	8	1	0	0	16	18	8
Namkum	3	34	11	0	2	0	0	33	8	2	39	3	—			—		
Katki 1944.																		
Barguttu	9	37	0	1	16	0	0	18	12	8	2	4	—			—		
Hesal	0	14	0	—			0	3	0	0	11	0	—			1	15	0
Berwari	5	15	1	0	4	0	0	26	14	4	24	3	—			13	39	6
Namkum	2	37	14	—			0	11	10	2	26	4	—			—		
Jethwi 1944																		
Namkum	0	4	8	—			0	1	2	0	3	6	—			—		
Hesal	0	4	8	0	3	8	0	0	12	—			—			—		
Berwari	0	0	11	0	0	10	0	0	1	—			—			—		
Aghani 1944-45																		
Hesal	0	1	0	0	0	14	0	0	2	—			—			—		
Berwari	0	0	8	0	0	8	—			—			—			—		
Total ...	79	9	9	1	27	8	13	29	3	63	32	14	1	0	0	45	4	8

		Rs.	As.	P.
(1)	Receipts by sale of brood lac 29 mds. 30 srs. 8 ch @ Rs. 42/- a md.	1,250	0	6
,,	by free distribution of brood lac 1 md. @ Rs. 42/- a md.	42	0	0
,,	by sale of brood lac 15 mds. 14 srs. @ Rs. 45/- a md	690	13	0
,,	by sale of scraped lac 32 mds. 2 srs. 15 ch. @ Rs. 30/- a md.	962	3	3
,,	by supply to lac factory of scraped lac 16 mds 3 srs. 12 ch. @ Rs. 30/- a md.	482	13	0
	Do 18 srs. 3 ch. @ Rs. 32/. a md.	14	8	10
,,	by sale of scraped lac 15 mds. 5 srs. 8 ch. @ Rs. 32/- a md.	484	6	6
,,	by supply of scraped lac to the factory 2 srs. 8 ch. @ Rs. 45/- a md.	2	13	0
	Total Rs.	3,939	10	1
By sale of scraped lac from purchased brood 32 srs. 3 ch @ Rs. 30/- a md.		24	2	3
Do	2 mds. 4 srs. 8 ch. @ Rs. 32/- a md.	67	9	6

GENERAL APPENDIX

(Entomological Section)

Tabulated statement of the progress of investigations

Item.	Cond. in	Progress during 1944-45	Future Work proposed.
Improving crop production on *Palas* by artificial defoliation.	1940	Results confirm success obtained in previous years.	*A new programme for the Section has been drawn up.* In addition to yield of brood lac total crop yields to be investigated.
Determination of most suitable pruning methods and seasons for Kusum, Ber and Palas.	Kusum 1941	*Kusumi* crops failed. However, six months old shoots gave as good results as those one and half year old.	Production of at least 3 crops necessary to establish the experiment.
	Ber 1942	In general to grow the *Katki* crop *Ber* should be pruned in February and to grow the *Baisakhi* crop in April. Preference to be given to pruning in the first half of these months.	Nil
	Palas 1942	Confirm previous years' results in general that shoots less than 1 inch and more than ½ inch in diameter should be pruned at least at a distance of one and a half foot from the base of each such shoot.	Most optimun time of pruming to be determined.
Investigating the economics of utilising *Palas* for the *Baisakhi* crop only and Ber for the *Katki* crop only.	1942	On Palas, brood lac survived in the *Baisakhi* crop but not on Ber unless the latter was partially pruned.	Trials for another 2 years necessary.
Mortality and fertility of lac insects.	1926 on young plants; 1940-41 on average sized trees.	2 Due to continuous extreme heat in the *Baisakhi* crop the fertility of both the *Rangeeni* crops was low.	Omitted from the new programme.
Bionomics and life history of *M. greeni* under controled humidity and temperature.	December 1942	Temperature seems to be more important than humidity.	Omitted from the new programme as a separate item.
Breeding of *M. greeni* on mass scale in laboratory.	1942		
(i) Mass breeding of natural & alternative hosts.		(i) *E. amabilis* was bred as well as collected. Among the alternative hosts borer of *Cassia fistula* (Amaltas) was introduced.	In the new programme breeding is chiefly to be done on alternative hosts. Most suitable alternative hosts remain to be discovered.
(ii) Mass breeding of *M. greeni*	1941	(ii) Breeding work suffered for want of proper equipment and failure of Kusumi crops.	Suitable incubators are necessary but there is no hope of getting them at present.

Item.	Cond in	Progress during 1944-45.	Future Work.
Releases of *M. greeni*	1941	55, 837 *M. greeni* of both sexes were released in four crops against 43, 158 of the previous year. Percentage parasitisation in every crop was over 100% more in the release area than in the control.	Does not figure as one of the chief problems in the new programme.
Artificial control of insect enemies by heat-treatment.	1941	Partial control was found possible. Optimum treatment between 52° to 62°C.	Optimum temperature, time to be determined.
(A) Demonstration of improved methods of cultivation and advice to cultivators.	Specific issues taken in 1940.	Brood lac distributed under different schemes. Partial pruning of Ber & partial defoliation of Palas preserved brood lac. Forest officers from Indian States and Institute Demonstrators were trained. Advice was given to cultivators.	Intensive and extensive demonstration necessary.
(B) Improved cultivation in forest areas.	1942	The scheme completed its first three years' sanction and ended with receipts Rs. 1,414 more than estimated at the time of inception, This is in spite of failures of 3 *Kusumi* crops.	Scheme has been extended for another 3 years.
'Ad hoc' investigations	1942	Dates of emergence of lac larvae were forecasted. Certain hosts to explore the alternative hosts of *M. greeni* were cultivated.	
Subsidiary investigations (i) Prospects of lac cultivation on *A. lucida* and *D. lanceolaria*	1938 & 1940	*A. lucida* yielded better brood & crop than *D. lanceolaria.*	In new programme some more hosts have been added.
(ii) Asexual breeding of female lac insects to evolve a better brood.	Restarted 1938	The eleventh generation is in the field.	Though a very important line of work it does not find a place in the new programme.

PRINTED AT THE UNITED PRESS LTD., BHAGALPUR.
1046—46—500.