

REPORT
OF
THE BOSE INSTITUTE
FOR
1952—53

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REPORT OF THE BOSE INSTITUTE FOR 1952-53

Governing Body. There were two meetings of the Governing Body during the year. The Governing Body has accepted with thanks a donation of £ 5,000/- from the executors of the estate of the late Mary Edith Keating, for the founding of a research fellowship to be maintained out of the annual income from the investment and to be named as Mary and Richard Keatings Research Studentship. The testatrix and her brother were friends of Acharya Jagadish Chandra since the time he went to England for study.

The Governing Body approved of the purchase of a property in Shamnagar, and sanctioned an overdraft against the securities of the Bose Institute for effecting the purchase.

Council. Two meetings of the Council were held during the year. Important decisions of the Council were (i) recommended the extension by one year of the period of service of the Director, Dr. D. M. Bose, which has been approved by the Government of India; (ii) authorized the general introduction from April, 1952 of the scale of pay recommended by the Vallarta Reviewing Committee; (iii) passed the audited accounts of the Institute for 1951-52 and the budget estimates for 1952-53; (iv) approved the creation of two Readerships, in Physics and in Microbiology, and two research fellowships, in Physics and Cytogenetics. The appointments will be made after additional grants are received for the purpose.

NON-RECURRING AND RECURRING GRANTS :

Non-recurring: The following capital grants were received during the year

Government of India for building purposes	Rs. 20,000/-
Government of West Bengal for purchase of land at Shamnagar for the Agricultural Experiment Station	16,667/-

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Recurring: The following recurring grants were received during the year

Government of India Rs. 1,50,000/-

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6,574/- Annual grant for training in scientific research

Grants-in-aid: The following grants-in-aid investigations are being carried out:

New Schemes. A new project on the use of C^{14} and P^{32} as radio-active tracers and as mutagenic agent has been sanctioned by the BRAE and work has commenced from March, 1953.

Schemes	Sponsoring Body	Grant received	Remarks
Impregnation of bleached jute with synthetic resins	Indian Central Jute Committee	9,738/-	
Mutagenic action of x-rays on Jute	"	11,074/-	
Mutagenic action of x-rays on oilseeds	Indian Central oilseeds Committee	22,135/8/-	
Cotton breeding investigations.	Govt. of West Bengal	7,800/-	
Weed control	Indian Council of Agricultural Research	4,007/12/-	new scheme commenced from January, 1953.
		54,755/4/-	
Cosmic Ray investigation	Board of Research on Atomic Energy.	51,445/6/6	
Nuclear Physics	"	22,132/-	
Neutron Generator	"	12,491/12/-	
Photographic plates	"	2,370/-	
		88,439/2/6	

Since October 1950 a plant pathological laboratory has been started in Mayapuri, Darjeeling with the object of investigating the viral, fungal and bacterial diseases affecting economic crops of the Darjeeling district. The officer-in-charge is a research fellow of the National Institute of Sciences of India. A scheme for placing this laboratory on a permanent footing was submitted towards the end of last year to the Ministry of Agriculture, West Bengal. It is understood that the scheme has been approved by the Ministry of Agriculture and is being examined by the Finance Ministry.

Deficit: The following figures taken from the audited accounts of the Bose Institute indicate a deficit of about Rs. 36,000/- incurred during the last four years.

Year	Income		Expenditure	Deficit
	Local	Government grant		
1950-51	47,566- 2-6	1,25,000- 0-0	1,81,031- 2-4	10,930- 1-5*
1951-52	47,974- 9-4	1,50,000- 0-0	2,02,694- 6-9	4,719-13-5
1952-53	43,000- 0-0	1,50,000- 0-0	2,17,784- 6-9	20,302-12-9
				35,952-11-7

* including deficit for 1949-50 of Rs. 3,395-9-4.

The gradual increase in expenditure is due mainly to (a) increase in the rate of the D.A. paid to the staff so as to bring it nearer to the scale approved by the Government of India; (b) upgrading the scale of staff salary upto that in force in other all-India Research Institutes and in the Universities, which was also recommended by the Vallarta Reviewing Committee in 1948. The scale of pay for example for Heads of Department under the recommendation of the previous Dunnicliffe Reviewing Committee was Rs. 400/- to Rs. 600/-, while that recommended by the Vallarta Reviewing Committee is Rs. 800-100-1000-125-1250. The Council's efforts to upgrade the scale of pay has suffered a set back due the unwillingness of the Government of India, who appointed Vallarta Reviewing Committee, to implement the latter's recommendations.

Building construction. A two storied block has been erected on the south west corner of the Institute quadrangle at an approximate cost of Rs. one lakh. For this purpose Rs. 40,000/- each has been received from the Government of India and the J. C. Bose Trust Fund No. I. The balance of expenditure has been met by a temporary loan. When installations are complete, it is intended to remove the workshop to the ground floor and the library to the first floor of the new building.

The plumbing, electrical wiring of the building as well as the purchase of library furniture will be taken up next year in the order of priority given above, as soon as funds permit.

Agricultural Experiment Station. In view of the difficulties encountered in acquiring, through Government agency, land at Falta for Farm extension, the Governing Body approved the purchase, from a single owner, of a property at Shamnagar containing more or less 40 bighas of good agricultural land with a tank, a small bungalow and out houses, at a cost of Rs. 55,000/-. The cost of purchase has been

met out of Government of West Bengal grant of Rs. 16,667/-, a loan of Rs. 20,000/- from the J. C. Bose Trust Fund No. 1 and an overdraft against the securities of the Bose Institute. The purchase has been completed by March 31, 1953. The property is near Barrackpore, within easy reach by train and bus services. It is near the Mulajore Power Station of the Calcutta Electric Supply Corporation. About Rs. 80,000/- will be required to develop the property as an experiment station. Later when the necessity arises, a part of the Biological laboratories of the Institute may be transferred there.

The land temporarily leased at Bamangachi will be vacated within a few months.

Acharya Jagadish Chandra Bose Memorial Lecture

The fourteenth lecture of the series entitled 'Growth of Scientific Spirit in Ancient India' was delivered by Dr. R. C. Majumdar, M.A., Ph.D., F.A.S. on November 30, 1952. The lecture has been printed along with the Director's Report presented to the 35th Anniversary meeting of the Bose Institute.

Other Lectures

Lectures were delivered in the Institute by Prof. (Madame) Suzanne Leclercq, Head of the Department of Botany, Leige University, Belgium, on the 'Story of the restoration of fossil plants' and by Dr. P. K. Bose, Director, Lac Research Institute, Ranchi, on "The Chemistry of Lac".

Visitors

Dr. Rajendra Prasad, President of the Indian Union and a former pupil of Acharya Jagadish Chandra visited the Bose Institute on December 30, 1952. After visiting some of the Institute buildings he placed a wreath on the *Samadhi* of Acharya Jagadish Chandra. Later he gave a short address to the workers of the Institute, assembled in the Hall of the Institute.

Among others the following visited the Bose Institute during 1952-53:

Mr. R. Colakovic, Federal Minister for Education and Culture, Government of Yugoslavia (Leader of the Yugoslav Goodwill Mission to India) and party; Prof. H. Grillo, Professor of Rural University and Member of National Council of Research of Brazil, Rio de Janeiro with Mrs. Grillo and Mr. D. J. Corsend, Brazilian Consulate, Calcutta; Dr. O. Schindewolf, Geology and Paleontology Institute, University of Tübingen; Mr. P. Evans, Chief Geologist, Burma Oil Company,

London; Lt. Col. A. N. S. Murthi, Chief Education Officer, Hq. Eastern Command; Hon'ble Dr. R. Ahmed and Sri K. K. Sen, I.C.S., Minister and Secretary for Agriculture & Co-operation, Government of West Bengal respectively.

STAFF CHANGES

The following were appointed scholars during the year:

A. Government of India Grant for training in Scientific research:—

Sri Smritimoy Bose M.sc. Junior Scholar—(Botany)
(vice Sri Apurba Kumar Ghosh resigned)

Sri Samir Kar M.sc. Ag. Junior Scholar—(Botany)
(vice Sri Gurupada Sen transferred)

B. Sir J. C. Bose Research Scholars:—

Sri Gurupada Sen M.sc. (Microbiology)
(vice Sri N. C. Das transferred)

Sri Ajit Banerjee M.sc. (Microbiology)
(vice Sri S. P. Sen resigned)

C. General Scholar:—

Sri Satyabrata Sircar M.sc. (Botany)

D. Birla Scholar:—

Dr. C. V. Ramakrishnan M.sc., PH.D. (Chemistry)
(vice Dr. D. P. Burma transferred)

Sri Syamapada Sen, Sir J. C. Bose Research Scholar joined the Purdue University, U.S.A. for higher studies. He was given a grant of Rs. 2,000/- only from Sir J. C. Bose Trust Fund No. 1, to enable him to complete his studies.

Dr. D. P. Burma was appointed a Research Assistant in Chemistry.

The following were appointed as Asst. Botanists in the I.C.A.R. Weed scheme:—

Sri K. George M.sc.

Sri M. G. Srivastava M.sc.

The following were appointed Junior Scientific Assistants in the Atomic Research Scheme No. I.

Sri N. C. Das M.sc. (from 1.3.52)

Sri N. N. Biswas M.sc. (from 4.5.52)

A. PHYSICS

A. 1. Measurement of Ultrasonic Power Output

A paper, entitled "On the generation of high intensity ultrasonic energy and the measurement of the output of ultrasonic energy of a quartz crystal", has been completed and has been sent for publication in the *Indian Journal of Physics*. An output of ultrasonic power of 42.2 watts/cm^2 has been obtained from an X-cut quartz crystal at frequency of 1000 kc/s.

A. 1.1. Magnetostriction transducer for ultrasonic energy:

Magnetostriction transducers for 100 kc/s. have been constructed. The stampings are made of permendur, an alloy of cobalt and iron in equal proportions, with about 2 percent vanadium; they are .004" thick and consolidated into stacks of 8 to 10 m.m. thick. The exciting coils are wound about two constricted sections in series and the stack is magnetised to saturation by a unidirectional surge of current through the exciting coils. It will be operated on remnant magnetisation. The design of the stack is such that it will vibrate as a half-wave *i.e.*, with a single node. When the whole stack is immersed in liquid, radiation from one face will be prevented by sticking to it a thin layer of closed cell rubber. The driver amplifier, having provision for a master-oscillator to drive the magnetostriction transducer, is under construction. The magnetostriction transducer will be coupled inductively to the coil of a tuned circuit by a secondary coil designed to secure approximate matching.

A. 1.2. Measurement of the relative intensity of light in different orders diffracted in a liquid medium traversed by ultrasonic energy:

A direct reading device has been made, by using a photocell R.C.A. 919, followed by a D.C. amplifier. Some sets of preliminary observations were taken. But the results obtained were not consistent. This was found due to some defects in the D.C. amplifier, photocell holder and the slit, through which light enters into the photocells. Modifications of the D.C. amplifier and photocell holder are complete. Special type of slit is being made in the workshop.

A. 2. High frequency positive ray discharge tube

A. 2.1. Setting up of a Neutron Generator:

The results obtained during the development of a radiofrequency type of ion source, have been summarized in the form of a paper which is now ready for publication.

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In order to utilize the ion source for the production of neutrons in D-D reaction, the work of installation of high voltage D.C. source for 150 kv in a voltage doubling circuit, has been undertaken.

The needle valve which was used for the regulation of the flow of hydrogen gas into the discharge tube of the ion source, has been replaced by a palladium tubing which when heated diffuses hydrogen and deuterium through the metal and exercises better control of the reproducibility and purity of the gases concerned.

A. 2.2. Radiofrequency Generator for high D.C. voltages:

An oscillator having a maximum power output of one kilowatt at a frequency of about 100 kilocycles/sec., has been assembled. Improvements in the tank coil design for delivering such a large power are still being carried out. A high Q coil has been inductively coupled to the tank coil for generating the primary voltage for the multiplication circuit.

With the components recently received from the U.K. the work of building up a multiplier stack for eightfold multiplication of the primary voltage, has been taken up. With an estimated primary voltage between 10 and 15 kv, the output from the multiplier circuit is expected to be between 80 and 120 kv.

A. 3. Cosmic ray investigations

A. 3.1. Study of time-variation of cosmic ray intensity:

A large cylindrical ionisation chamber (vol. 30 liters) filled with argon at a pressure of 50 atmos. has been fitted up along with a Lindemann electrometer for the study of time variations of cosmic ray intensity involving diurnal, seasonal and sudden variations associated with solar flares and geomagnetic disturbances. A camera to record photographically the movement of the Lindemann electrometer is under construction.

A. 3.2. Study of "Fragmentation type" of cosmic ray bursts:

Records of cosmic ray bursts have already been taken using a small ionisation chamber (vol. 1.8 litres) filled at different pressures of argon, ranging from 1 atmos. to 14 atmos. An analysis of the records is being undertaken for investigating the size frequency distribution curve of bursts. Records of bursts will now be taken using hydrogen and nitrogen gas instead of argon with the same chamber.

A. 3.3. *Study of cosmic ray showers:*

Records of cascade type of bursts and penetrating showers along with small bursts (fragmentation type) have been taken with another ionisation chamber (vol. 5 litres) filled with Argon at a pressure of 250 lbs. per sq. inch. A G.M. counter system will be installed along with the chamber to differentiate atmospheric showers from the fragmentation type of bursts originating within the chamber wall and the gas volume. All these assemblies will be taken to our high altitude station at Darjeeling very soon.

A. 3.4. *Construction of a large electromagnet for cloud chamber investigation:*

An electromagnet, consisting of six coils and two E-shaped pole-pieces is under construction. The coils have been wound by making a special gadget in the workshop, and the pole-pieces have been cast in the Ishapur Metal Factory. They are now being machined to the desired dimensions so that the two coil frames (each containing three coils) can be fitted into the central conical studs of the E-shaped pole-pieces. The magnet will give 10,000 gauss consuming about 25 kilowatt. A 110 volt 25 kv generator has been purchased for this purpose.

A. 3.5. *Nuclear interaction of the N-component in lead:*

A square cloud chamber ($24'' \times 24'' \times 12''$) with eleven $\frac{3}{16}''$ lead plates has been constructed for the study of nuclear interaction of the N-component of cosmic rays in lead. A penetrating shower detector comprising of three coincidence channels and one addition channel has been set up. A 15 cm. lead absorber placed just below the first tray of counters forms the shower producing layer. The addition channel placed beneath the chamber requires at least two particles to come out of the chamber. The coincidence rate under this condition is about two per hour at Calcutta and is expected to be about fifteen per hour when the apparatus will be worked at an altitude of 7,000 ft. (Darjeeling). The control circuit and all other accessories of the cloud chamber are working satisfactorily and actual photographing of the showers will start as soon as flash tubes for the illumination of the cloud chamber arrive.

A. 3.6. *Mean life of μ -mesons:*

Measurement of the mean life of μ -mesons is being carried out by the method of delayed coincidence. The integral decay curves for a composite beam of mesons (both positive and negative) have been determined in cases of aluminium and carbon. The thickness of each absorber has been selected so as to stop the same number of mesons in

each case. Under this condition, the results so far obtained are summarised below:

Absorber	Mean life in microseconds				Capture probability ($A = \frac{1}{\tau_-} - \frac{1}{\tau_+}$ in $\text{sec}^{-1} \times 10^{-5}$)
	Composite Beam (τ)	Positive mesons τ_+	Negative mesons τ_-	τ_- according to Wheeler's theory	
Al	$1.85 \pm .07$	$2.24 \pm .08$	$0.87 \pm .07$	0.77 ($Z_0=10$)	7.0 ± 1.1
C	$2.05 \pm .08$	$2.22 \pm .02$ (assumed)	$1.94 \pm .08$	1.93	$.65 \pm .14$

The experiment is in progress with absorbers of higher atomic number.

A. 4. Nuclear Physics

A. 4.1. Determination of the total Gamma ray absorption cross section:

The present series of experiment is aimed (i) to determine precisely the total gamma ray absorption cross-section of various elements and (ii) to examine critically the reported anomalous variations in absorption cross-section at high absorber thickness. Absorption coefficients for various elements like copper, aluminium, lead etc., have been determined. These absorption coefficients show agreement within 0.5 per cent of their respective accepted values. Due to the difficulty in obtaining elements in chemically pure form, absorption coefficients of various elements are now being deducted by determining the absorption coefficients of very pure compounds of those elements. Attempts are being made to procure tantalum compounds to verify Davisson and Evans' reported discovery of an anomalous absorption coefficient for this element.

In order to eliminate counting loss at the high counting rates a scaler has been designed and constructed. It is working satisfactorily. For greater precision of measurement a novel type of coincidence gamma counter has been devised. With this arrangement it is hoped to gain a much larger ratio of gamma coincidence to background counts than is possible in ordinary coincidence arrangement. To explore anomalous absorption coefficients at large absorber thickness (~ 20 cms. of lead), we are trying to get RCA 5918 photomultiplier tube with its accessories from the U.S.A. So far measurements in various elements have revealed no anomalous behaviour in absorption cross-sections.

A. 4.2. *Determination of Slow Neutron Cross-section:*

A new series of data with Indium foil is being obtained for various samples available, using end-window beta counters constructed in this laboratory. We are trying to procure borazole ($B_3N_3H_6$) from abroad. This compound along with p-xylene will be used as counting liquid for slow neutron scintillation counter.

A. 5. Radioaction Tracer Technique

A. 5.1. *Use of C^{14} and P^{32} as tracers in plant metabolism and as mutagenic agent:*

The scheme was sanctioned from March 1, 1953, but as no suitable plant physiologist could be found the work will start from May 1, 1953. A radio physicist is being trained in radiochemical methods and the use of G.M. counter and ionisation chamber measurement methods.

It is proposed to study the intermediate metabolites formed during the synthesis and breakdown of carbohydrates in plants by means of radioactive tracers, like P^{32} and C^{14} . For this purpose, radioactive $BaC^{14}O_3$ has been imported and the arrival of radio active $Na_2HP^{32}O_4$ is expected from Harwell very soon.

A. 5.2. The mutagenic action of β -radiation P^{32} will be studied by absorbing $Na_2HP^{32}O_4$ solution in roots of seedlings of different growing plants.

B. CHEMISTRY

B. 1. Physical Chemistry

B. 1.1. *Electrophoresis apparatus:*

The construction of a Tiselius Electrophoresis apparatus which was taken in hand sometime in September 1952 has been partly completed. Some of its major components are now nearly ready, and the rest are being made.

The redesigned optical bench in which a pair of 20' long solid cylindrical shafts has been substituted for steel channels, has been temporarily set up on C.I. stands and this in the final stage will be erected on vibration-proof concrete bases in the new air-conditioned room.

The thermostat and the support for the cells and electrode vessels need some minor changes and improvements which are being carried out. Orders for the all glass electrode vessels will be placed as soon as the support is ready.

The construction of the slit for the light source has also been completed. The high pressure Hg-vapour lamps for which orders were

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The construction of the slit for the light source has also been completed. The high pressure Hg-vapour lamps for which orders were

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placed in January, however, will soon be received. Among the important items which still remain to be taken up or completed are, the camera with all its accessories *viz.*, the tube, the schlieren diaphragm, shutters, mountings etc., the driving mechanism with its motor for the schlieren diaphragm and the camera plate, the driving mechanism for the camera shutter and for the compensator device in the thermostat assembly, the thermoregulator and the relay and stirrer for the thermostat.

It is expected, however, that the apparatus would be ready at least for preliminary assembly and test within a couple of months.

B. 1.2. Chromatography:

The technique of paper-ionophoresis has been introduced in these laboratories and is being applied to various types of problems. The field of application of the technique of paper chromatography, already developed here, has been further extended within the year under report. Circular paper chromatographic technique has also been introduced to study the phosphorylated intermediates in plant metabolism. The techniques of paper chromatography and paper ionophoresis have been applied in combination to carry out 'electrochromatography'.

B. 1.2. (a) Paper-ionophoresis:

The equipments used for this purpose are of two types (1) Durrum's equipment in which papers are placed in an inverted V position. Durrum's equipment has been much simplified by using a paraffin-coated wooden base, bell-jar and glass-frame, (2) McDonald's equipment, in which paper strips are placed in horizontal position. The one constructed here consists of an airtight box made of perspex with a heavy glass lid, perspex buffer vessels and a glass frame to support the paper strips. Studies on ionic mobilities are being carried out with the latter type of equipment which gives reproducible values, though for ordinary separation purposes the former seems suitable. It has been observed with purines, pyrimidines and alkaloids that their movements are linear with time.

Application of the technique of paper-ionophoresis to the study of the constituents of nucleic acid.

Before subjecting the nucleic acid hydrolysate to paper ionophoresis, the conditions for the separation of the purines and pyrimidines, the constituents of nucleic acid were studied in detail. For the detection of the purines and pyrimidines the 'Chromatolite' lamp has been used. The 'Chromatolite' lamp which is an ultraviolet lamp emitting 2537 Å radiation and is specially designed for chromatographic purposes has been recently purchased. Purines and pyrimidines appear as

blue-black spots on a fluorescent background due to quenching of the fluorescence of paper in those regions.

After trials, citric acid-phosphate buffer of pH 2.2 was found to be suitable for the separation of the bases purines and pyrimidines. An average current of 0.15 mA flowed through each strip when 220 volts were applied. Guanine, adenine and cytosine were found to move towards the cathode while thymine and uracil remained practically stationary at the original starting line. Thus, separation of thymine and uracil was not possible under such conditions; fortunately, however, they do not occur in the same nucleic acid. Though 2 hours were quite sufficient for separation of either guanine and adenine or guanine and cytosine, 6-8 hours were required for separation of adenine and cytosine. An 8 hours' run of a mixture of uracil and/or thymine, guanine, adenine and cytosine was found to be quite sufficient for their definite separations. Average distances are uracil and thymine, 0 cm., guanine 11-12 cm., adenine 15-16 cm., and cytosine 17-18 cm.

Thymine and uracil were separated from each other by using alkali solution as the conducting medium. The bases are applied as sodium salts by dissolving them in alkali. Using N/10 alkali the two just separate in about 8 hours uracil being a bit ahead of thymine (uracil 10-11 cm. thymine 9-10 cm.). Run for longer hours did not improve the results, instead created disadvantages due to considerable electrolysis. Using stronger alkali (N/5), separation can be effected in shorter period (4 hours), uracil being a bit ahead of thymine (uracil 4-5 cm., thymine 3-4 cm.).

In this case too, run for longer periods failed in effecting better separation.

For study of the constituents of yeast nucleic acid it is was first subjected to hydrolysis with 70% perchloric acid. The hydrolysis was carried out in a sealed tube which was heated in a boiling water bath for about four hours. The free bases so released were separated and detected by paper ionophoresis. By carrying out paper ionophoresis at pH 2.2 adenine, guanine, cytosine, uracil and/or thymine were detected. By using N/10 alkali as the conducting medium the presence of uracil and the absence of thymine was established as was expected in the case of yeast nucleic acid. The method thus developed can be very conveniently applied in studies on the nature of nucleic acids isolated from any source.

Separation of the alkaloids by paper ionophoresis:

Attempt is being made to separate a number of alkaloids by ionophoresis on paper. Alkaloids are detected either due to their fluorescence or due to quenching of the fluorescent paper when exposed to

ultraviolet source emitting 2537Å radiation. Acidic pH is found to be suitable for separation of most of the alkaloids. Quinine and cinchonine are however ionophoretically separated from each other at alkaline pH only. The work is in progress.

B. 1.2. (b) Paper Chromatography:

One-dimensional as well as two-dimensional techniques have been successfully applied in the following problems.

Organic Separations.

A number of organic acids as formic, citric, oxalic, tartaric, benzoic etc., have been separated in the form of their sodium salts with phenol-water, alcohol-water, acetone-water pyridine-water, dioxan-water as the developing solvents. After development of the chromatograms the papers are sprayed with zinc-uranyl acetate solution and then exposed to ultraviolet light when the sodium salts of the acids appear as bright fluorescent spots.

Acids belonging to the Krebs cycle have been separated two-dimensionally using phenol-water as the first solvent and benzyl alcohol-acetic acid-water (25 : 5 : 6.5) as the second solvent. Free acids were applied on paper and alcoholic solution of bromophenol-blue, made slightly alkaline with caustic soda was sprayed on the developed chromatogram. Acids appear as yellow spots on bluish background. This technique is being standardised for the study of the free acids occurring in plants and study of their role in the metabolic pathway.

Paper Chromatography of Sugars.

Mixtures of non-aqueous solvents such as, pyridine acetone, and ethylene glycol-cellosolve, have been used in the unidimensional development of the chromatograms of sugars with the object of finding out whether some suitable second solvent for carrying out two-dimensional chromatography of sugars can be substituted for the aqueous solvents, which in most cases are not very satisfactory. With pyridine alone all the sugars move with the solvent front and with acetone alone they remain stationary at the original starting line. With pyridine-acetone mixtures, however, the R_F values depend upon the pyridine-content of acetone; the R_F values increase with increase in pyridine content, just as they do in the case of aqueous developing solvents with increasing water content. Similar are the observations with ethylene-glycol-cellosolve mixture; for instance, with ethylene glycol the sugars move more close to the solvent front and with cellosolve they move very little, whereas with mixtures of the two, the R_F values depend upon ethylene glycol content. No composition was, however, found to be suitable for purposes of separation.

B. 1.2. (c) Circular Paper chromatography in the study of phosphoric esters in plants.

The phosphate esters occurring in mungbean seedlings were extracted by the usual method of Umbréit. Barium soluble and barium-insoluble alcohol-soluble fractions were separately subjected to circular paper chromatography. In both the fractions a number of phosphate esters have been detected. The work is in progress. Application of radioactive phosphorus to study the phosphorylated intermediates in plants is aimed at. Paper-autoradiography will reveal the path of phosphorus in plant-metabolic processes. (see C. 1).

B. 1.2. (d) Electrochromatography.

The term 'electrochromatography' has been used to specify the cases where chromatography and ionophoresis are simultaneously applied for the separation of the constituents of a mixture. While a paper-chromatogram is being developed unidimensionally electric field is applied either in the direction of flow of the developing solvent or at right angle to it. In the case of amino acids, for example, the filter paper is previously treated with buffer at the required pH and the developing solvent too is saturated with it. Colloidal graphite impregnated on the two sides of paper serve as electrodes.

A detailed study with a number of amino acids at different pH with phenol-buffer as the developing solvent has led to interesting results. On ordinary paper acidic amino acids move towards the anode, basic ones towards the cathode, neutral amino acids do not move at all. On buffer-treated papers, however, the movement depends upon pH interval between the buffer and isoelectric point of the amino acids. For instance, leucines move towards the cathode at pH 2 but move towards the anode at pH 6. By choice of suitable pH and application of electric field in proper direction, amino acids characterised by very close R_F values (excepting however isomers) can be separated from one other.

The results and observations made above can be substantiated and considerably improved if the technique of 'Counter-current Distribution' is introduced in these laboratories, which is under active consideration.

B. 2. Biochemistry

B. 2.1. Isolation of cell nuclei from the endosperm of Cocos nucifera and Borassus flabellifer (Bengali: Tal) and determination of their constituents:

This investigation was undertaken following the work of Cutter, Wilson and Dube' (*Science*, **115**, 58, 1952) on the isolation of nuclei from

the endosperm of *Cocos nucifera*. They showed that prior to cellular differentiation, the nuclei which are relatively large, are loosely embedded in a gelatinous cytoplasmic matrix and this stage was ideal for the isolation of living, undamaged nuclei. The method of isolation described by them consisted in homogenizing the jelly like endosperm in a Waring blender in cold 4% sucrose medium, filtering through several layers of cheese cloth in order to remove the cell wall debris and coarse fragments, diluting and filtering again through cotton wool pads in which the nuclei were trapped and fine cytoplasmic matter passed through, then finally recovering the nuclei by drawing through the pad with strong suction cold sucrose solution which brought down the majority of the nuclei. The filtrate was then centrifuged at a low speed when the nuclei separated at the bottom. All stages of the experiment were carried out in cold.

The proposed work envisaged the isolation of nuclei by the above procedure and determination of the nature of some of their constituents, namely the proteins and nucleic acids with the help of paper chromatography and other available methods.

Following this method and starting with about 100 gms. of wet material (equivalent to about 8 young coconuts) very small quantity of nuclei could be obtained after centrifuging, although according to Cutter *et. al.* 0.13 gm., of undamaged nuclei could be isolated from 43 gms. of gelatinous endosperm. Moreover, when examined under the microscope with appropriate stains, it was found that though the isolated portion contained a very large proportion of whole undamaged nuclei there was present alongside with these a fair amount of cytoplasmic and other contaminants originating probably in the cell walls. The method was repeated several times without, however, much improvement both in respect of yield and purity. The yield could be improved by omitting the step of filtration through cotton wool pads and resorting to filtration through cheese cloth and centrifuging the filtrate at different speeds,—a practice generally followed with animal systems. But here, the purity was less satisfactory as preliminary tests showed. This modified procedure would probably give better results with more careful regulation of centrifuge speeds and at present it is being tried by making changes as required.

The original method of Cutter *et. al.* has not however, been abandoned but as the filtration and other steps in the method take somewhat longer time and also the bulk of liquid required to be handled is not inconsiderable, it will be tried when the cold room or the air-conditioned room is ready for working.

Results obtained with the endosperm of *Cocos nucifera* and *Borassus flabellifer* were similar. As a matter of interest it may be mentioned

that whereas the nuclei of the endosperm of *Cocos nucifera* underwent a fair amount of disintegration when blenderised, those of *Borassus flabellifer* withstood blenderisation much better and to that extent the latter was much easier to work with.

Further work along these lines is in progress.

B. 2.2. Enzymes

B. 2.2.1. A device to grow *Aspergillus niger* mold on a large scale:

Since *A.niger* mold mat was required in large quantities for further work on the purification of enzymes present in them, a cheap, circular galvanised iron tray of 12" diameter and 6" height with suitable airtight lid and opening for inoculating the medium with spores has been devised. It is possible to get about 40 gms. of mat from each tray and four of such trays can be autoclaved at a time.

B. 2.2.2. Effect of the culture medium on lipase and esterase activities of *A.niger*:

A study was undertaken to find ways and means to concentrate the enzymes in the mold before an attempt is made to separate them. It is found that strains of *A.niger* which possess almost no lipase and esterase activities show a tremendous amount of activities of these two enzymes, when they are first, grown twice or thrice in agar medium containing 2% fresh groundnut oil and 10% mold filtrate before they are grown in the usual cake medium. This suggests the possibility of a chemical mutation having taken place. This method will be very useful to get a strain of *A. niger* with high lipase and esterase activities.

B. 2.2.3. Purification of lipase powder obtained from *A.niger*:

As a first step in the purification, an attempt was made to increase the concentration of lipase and esterase in the water extract of mold lipase powder. By AmSO_4 fractionation, it is possible to purify them 20-40 fold. Even though lipase and esterase get purified to different degree, still they are present in the same fraction. During this crude AmSO_4 fractionation, lot of undesired proteins are removed. Gel method is being tried to separate lipase and esterase.

B. 2.2.4. Spectrophotometric method for estimating enzymic synthesis of Butyl oleate:

A simple assay system has been worked out to estimate the percentage synthesis of butyl oleate using microquantities (.005 M Butylalcohol, .005 M Oleic acid, 0.1 gm. Lipase) of the ingredients within 2 hours in Beckman Spectrophotometer by studying the absorption at 405-410 m μ .

B. 2.2.5. Lipase and esterase activities in X-ray irradiated sesamum seeds:

When sesamum seeds were irradiated with 140 m.a.H. it has been observed that lipase activity tends to go down whereas esterase activity goes up which indicates the possibility of getting a mutant rich in one group of enzymes and devoid of the other group by using x-ray irradiation technique.

B. 3. Chemistry and microbiological studies on Jute fibres

B. 3.1. Microbiological study:

In continuation of previous work on isolation of different strains of micro-organisms responsible for the retting of jute, efforts were made to obtain active strains from sources other than retted jute and retting water. Various rotting fruits were collected and isolation of different bacteria and fungi were made by the usual process of repeated agar plating. They were then studied individually for their activities on jute plants in aseptic conditions. Several strains of bacteria and fungi capable of retting jute were isolated in pure condition, of which two strains of fungi were found to be the most active, retting being completed in 48 hours. They were identified as two strains of *Aspergillus niger*.

Various fungal media were tested for studying the activity of the isolated strains of fungi and it was observed that in the media in which there is no other extra supply of carbohydrate than jute stems alone, the retting capacity of the microorganism is the greatest. Any addition of sugars seemed to hinder the process of retting, though the growth of the fungus became more vigorous.

Attempts will be made to isolate more of the active strains and also to characterise the organisms isolated.

B. 3.2. Biochemical study:

The present work was carried out to study the effect of enzymes from six different strains of fungi on pectin like substances in jute, binding the fibres to the bast. Three of these fungi were isolated in this laboratory and three other fungi were standard cultures of *Aspergillus oryzae*, *Penicillium expansum* and *Botrytis cinera* respectively which had already been reported to have pectin-splitting activity.

Jute pectin was extracted from the jute stems by the following method. The bast was mechanically separated from the stem, cut into small pieces, washed with water, treated with alcohol and dried. The dried pieces were extracted with 0.5% ammonium oxalate at 80°C. for four hours and filtered. To the filtrate was added acidified alcohol, when pectin was precipitated as jelly like substance. The precipitate was filtered and washed with graded alcohol. The residue was then

taken in water and treated with 0.7% sodium chlorite solution and heated on a water bath to remove the lignin. The lignin free pectin was then precipitated with alcohol, filtered, washed with ether and dried. The pectin thus purified was found to have methoxyl content of not more than 4%.

The polygalacturonase enzyme was prepared from wheat bran cultures of different fungi; sterilised wheat bran was inoculated with spore suspensions of each of the six fungi. At the end of 3-4 days, the material was extracted with distilled water, strained and centrifuged. The enzyme was precipitated with alcohol, filtered and dried.

The action of six different enzymes, prepared in this laboratory, was studied on both jute and citrus pectin of low methoxyl contents. Their breakdown products were identified by means of paper chromatography with phenol water as developing solvent. Galacturonic acid was found to be the main breakdown product in the case of both jute and citrus pectins. This was identified by its R_F value and was finally confirmed by co-running pure galacturonic acid as also acid-hydrolysate of both the pectins as 'standards'. Very faint spots with R_F values corresponding to different sugars mainly pentoses were also found in the chromatogram which might be due to substances adhering to the pectins themselves.

Attempts were also made to separate the different intermediate products formed in the course of break down of pectins to galacturonic acid by arresting the hydrolysis at different intervals of time. The hydrolysates were subjected to paper chromatography but on each occasion galacturonic acid was found to be the only product of hydrolysis. This might be due to the very complex nature of the bran enzyme. This work will be repeated with enzymes prepared by the submerged culture method. The complex nature of the pectin-splitting enzymes are also being studied.

B. 3.3. Analytical studies of R. 26 Control and Tall Mutant jute fibres:

The furfural and polyuronide contents of R-26 control and Tall Mutant retted jute fibres were estimated. The results of the analysis are recorded below*:

S. No.	Constituents	Particulars of sample used	Average percentage	
			R-26 (Control)	Tall Mutant
1	Furfural	Dried and non-defatted	9.26	9.46
2 (a)	Uronic CO ₂	do.	1.145	1.18
(b)	Polyuronides	do.	4.58	4.72

* The results of other estimations with such fibres were published in the Annual Report for 1951-52.

B. 3.4. Action of Nitrogen Peroxide on Jute holocellulose:

From the results of experiments conducted by earlier workers it has been assumed that in plant cell-wall the progressive oxidation and decarboxylation of hexosans would in fact result in polysaccharides of the nature of polyuronide hemicelluloses.

The first stage namely the oxidation of hexoses to hexuronic acid can be easily accomplished by the production of a few polyuronide groups in the hexosan chain of the cellulose but the second stage *i.e.*, the decarboxylation process is not yet proved. Biological means as well as heating with water under pressure have been tried for decarboxylation process, but no direct evidence of the formation of pentose could be given.

Experiments can be conducted to see if by oxidation, COOH groups formed in the jute holocellulose which on decarboxylation by suitable process gives rise to pentosan only. If this is achieved then it may give some idea on the formation of hemicellulose in nature.

Nitrogen peroxide is chosen as the oxidising agent because it was already used to oxidise cellulose. Yackel and Kenyon (*J. Am. Chem. Soc.*, **64**, 121, 1942) oxidised cellulose with nitrogen dioxide at 21°C. to produce a new type of oxidised cellulose containing more than 13% COOH group content. Unruh and Kenyon (*J. Am. Chem. Soc.*, **64**, 127, 1942) found that the COOH group contents of the oxidised materials reach a limiting value of about 25%. The calculated limiting value of polyanhydroglucuronic acid is 25.5% COOH. The results of their experiments indicated that NO₂ preferentially attacks the primary hydroxyl groups of the cellulose to yield oxidised materials containing uronic acid units.

Retted jute fibres were defatted with alcohol benzene mixture and delignified by sodium chlorite method. The dried holocellulose was taken in a glass flask and evacuated. The nitrogen peroxide gas (prepared by the action of cold and conc. HNO₃ on copper-turnings), dried over P₂O₅, was drawn into the flask. The substance kept in contact with the gas in the closed system for different intervals of time. The gas is then drawn out of the flask, dry air blown in and the substance washed with water and air dried. Its COOH content as determined with calcium acetate method was about 7%.

It was noticed that there is a considerable loss in weight of the substance undergoing oxidation. It might be due to the water soluble products of degradation resulting from the oxidation of cellulose and hemicellulose. A higher temperature used in this case or presence of moisture in the reaction system might have given rise to side reactions. The wash-water obtained from the oxidised product was yellow in

colour which on slow evaporation gave rise to a yellowish brown residue. The sample was repeatedly washed with water to free it from the adhering acidic constituents. The wash water was always acidic in character, though negligible in last stages. The yellowish brown residue obtained above gave a positive test with orcinol reagent indicating the presence of a pentose unit. Application of paper chromatography to aqueous solution of the residue showed a brownish red spot not so well defined. The purification of the aqueous solution is a pre-requisite for the identification of this unknown substance.

The oxidation was also tried by the following method:

Nitrogen peroxide gas dried by P_2O_5 was led into a conical flask containing the holocellulose for a few hours at a temperature of about $0^\circ C$. A bluish-green condensate was produced on the fibre which was stirred occasionally. The flask is then stoppered and kept in the atmospheric temp. (about $34^\circ C$.) for a good length of time. The fibre was washed with water and air-dried. It gave a COOH group content of 15.5% whereas that of holocellulose gave 1.3% as determined by calcium acetate method. This product was readily soluble in dilute NaOH. From a comparison of the nature and characteristics of the fibre, it seemed that the oxidation process was somewhat drastic.

The above methods of oxidation are being modified suitably to achieve a limiting value of COOH group content with minimum of undesirable reactions.

B.3.5. The Impregnation of bleached jute yarns with suitable synthetic resins:

The object of this investigation is to improve the wet strength of bleached jute yarns.

Best results were obtained with melamine resins. The process has been somewhat simplified (1) by avoiding the use of vacuum used previously and (2) by the use of waste resin solutions left after first impregnation process. Ageing of resins for 72 hrs. has been found beneficial.

Use of silicon-esters and amino-silanes along with melamine resins did not improve the wet strength as expected.

Ciba 286 has been found to give satisfactory results. The improvement is of the same order as found with melamine resins.

A few samples of bleached yarns, supplied by Dr. W. G. MacMillan of IJMARI were treated but did not show any improvement. On testing it was found to have high lignin content which resisted penetration by resin solutions. The resins were therefore deposited mostly on the surface and this tended to reduce rather than augment the wet strength.

B. 4. Organic Reactions

- B.4.1.* Alkylation of aliphatic compounds with reactive methylene groups has been affected by using anhydrous aluminium chloride as the catalyst. This method dispenses with the use of sodium ethoxide and gives a better control of the reaction.
- B.4.2.* Knoevenagel reaction involving the condensation of reactive methylene groups with carbonyl compounds, has been effected with piperazine and piperidine diacetate as the catalysts. These catalysts have been found to promote the condensation of levulinic ester, β -acetoglutaric ester and mesityl oxide with cyanacetic ester.

The effects of different factors such as use of solvents and pH are being studied.

B.4.3. Organic synthesis:

Good progress has been made in the attempted synthesis of depanthic acid a degradation product of the arrow poison—strophanthidin. The final product has not yet been obtained.

- B.4.4.* Attempts are being made for the synthesis of estrone, based on trans addition of hydrocyanic acid to an $\alpha\beta$ unsaturated ketone synthesised in the laboratory. Work is progressing satisfactorily.

C. BOTANY

C.1. Plant Physiology

C.1.1. Effect of auxins on the respiratory systems of Avena coleoptile:

Due primarily to pressure of work on other branches little further work has been done on the effect of auxins on plant respiratory systems during the present year. However, seeds of the standard 'Victory' strain of oats was obtained from East Malling, England. Unfortunately the percentage germination of these seeds were much too low to permit any systematic work with this material. Some of the seeds were sowed in the Bamangachi field station of the Institute and fresh grains are due to be harvested soon. As soon as a good crop of Victory avena is obtained the respiratory work will be taken up.

C.1.2. Study of phosphate compounds and associated enzymes in plants;

In last year's report it was mentioned that the method of estimation of total phosphorus, inorganic phosphorus and organic phosphorus in plant materials had been standardised using avena coleoptile as the

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test material. The estimation is mainly based on the principle of fixing the phosphorus with ammonium molybdate to form amm-phosphomolybdate and subsequent reduction of the phosphomolybdate compound to obtain the molybdenum blue, the colour of which is proportional to the quantity of phosphate present. The colour is estimated on the Beckman Spectrophotometer and from a comparison of the optical density of the colour to a standard curve of optical density, the amount of phosphate is read off.

During the year under report this method of estimating inorganic phosphorus has been further standardised using germinating seeds and seedlings of gram, pea and mungbeans.

Further attempts have been made to fractionate the organic phosphorus compounds into definite fractions known to contain defined phospho-esters. For this purpose the standard method of separation of the esters as Barium salt, using the different solubilities of the Barium salts has been adopted. Due to the presence of a large proportion of interfering substances in plant extract, the procedure B of Umbriet *et.al.* has been adopted successfully to separate the phospho-compounds into the 'Barium insoluble' fractions which is supposed to contain ATP, ADP, F-1-G-diphosphate, and phosphoglyceric acid and the 'Barium soluble alcohol insoluble' fractions containing G-1-phosphate, G-6-phosphate, AMP, etc. For this purpose embryos from germinating seeds of pea, gram and mungbean has been successfully used.

The presence of ATP in the Ba insoluble fraction of pea and mungbean extracts has been confirmed with circular partition paper chromatography and using the same technique, presence of at least three phosphoesters has been demonstrated in the Ba soluble alcohol insoluble fraction. These may be any of G-1-P, G-6-P, AMP etc and has yet to be confirmed against standard substances.

Chemically, the presence of appreciable quantity of labile phosphates has been established in both the fractions indicating the presence of different organic phospho-compounds. The detail method of quantitative estimation of the different fractions on the basis of detailed chemical analysis of nitrogen, purine, labile phosphorus, and pentose is being standardised.

Interesting report on this branch of study has recently been made by Dr. Albaum of Brooklyn, who, using radioactive orthophosphate has established the presence of labelled ATP, ADP, G-1-P, G-6-P etc. in mungbean seedlings. Preliminary experiments are being undertaken to use similar technique to demonstrate the presence of different labelled phospho-compounds in different plants and also to follow the course of synthesis of the phosphoesters in plants. For this purpose a consignment

of 5 mc. of P^{32} is expected soon. This technique, successfully applied, is likely to yield valuable information on the phosphorus metabolism in plants.

C.1.3. Growth of excised plant tissue:

In last year's report, it was stated that a study of carbohydrate and aminoacid metabolism has been taken up using excised plant tissues as test materials. For this purpose standard conditions were established for growing excised tomato root tips in artificial medium for indefinitely long periods. The medium is essentially that suggested by White (1943) but Vitamin B₆ has not been supplied and requisite quantity of ferric chloride has been used to replace ferric phosphate. At later stages of growth (from 9th transfer onward) 0.005 p.p.m. of Cu as copper sulphate and 0.001 ppm. molybdenum as ammonium molybdate, both reported to be beneficial by Boll & Street (1951) have been used with advantage. It has been possible to grow tips for more than 20 passages and the clones are growing vigorously. The clones established are generally transferred at weekly intervals and the rate of growth is found to be not less than 9 mm./culture/ day. The growth is however markedly affected by changes in pH of the medium and the temperature of incubation. The initial pH of the medium is 4.6 and after a week's growth of the root, this value changes to about 6.0. The temperature of incubation is generally $25^{\circ} \pm 1^{\circ}C$ and a rise in temperature irreversibly damages the roots in a few days, while a lower temp. only retards their growth.

It has been found that only 3 mgs/litre of glycine in the culture medium may serve as the only source of organic nitrogen very satisfactorily in transfers lasting over a few weeks. A mixture of amino acids as prepared by acid hydrolysis of casein and confirmed by paper chromatography to contain 18 different acids was used in the medium as the source of organic nitrogen (in quantity of equivalent nitrogen). During the first week of growth, this mixture induced significantly better growth (80% increase over average) but in later stages materially retarded the growth of the same tips. Somewhat similar result was obtained with l-cystine.

Of the 18 amino acids identified in casein hydrolysate glycine, cystine, lysine, tyrosine and glutamic acid have been reported to be stimulatory; aspartic acid, histidine, methionine, phenylalanine, and leucine to be indifferent; and hydroxyproline, proline, valine, alanine, arginine and tryptophan to be inhibitory (White, 1937). Whereas the role of asparagine and threonine, also found in the casein hydrolysate, is not well understood.

However White's conclusion was based on the growth of the roots in the amino acids only for a single passage. Whether the same effect

of the amino acids on the growth of excised roots persists on continued passage may be questioned on the basis of our experiment of continued growth in presence of casein hydrolysate and L-Cystine and merits careful consideration. This question is being further studied.

A careful analysis of the amino acids present in the root tips fully grown in artificial medium is likely to throw interesting light on the nitrogen metabolism of the excised roots and is going to be taken up.

In addition to root tips preliminary attempts to grow excised embryos are also being made. Embryo-culture in artificial medium is helpful in the understanding of the nutritive requirement during embryonic growth and differentiation and also in the artificial production of different hybrid combination. Embryos of wheat, barley, rye, oat, maize etc. have been successfully grown *in vitro*, but no attempt has yet been made to establish the necessary conditions for growing embryos of rice, one of the major cereal crop of the world. For this purpose embryos from rice grains of an 'Aman' and a 'Boro' variety are being tried at present for preliminary experiments.

The grains are dehusked, sterilised in hypochlorite solution, and allowed to germinate on moist filter paper in petri dishes under aseptic conditions. When the embryos started growing they are removed and transplanted on artificial nutrient medium; this is done before sprouting takes place.

After a trial with a few media, it has been observed that rice embryo, when completely freed from adhering endosperm tissue is incapable of growing on a medium containing only inorganic nutrient and sugar. Present indication is that growth is possible when glycine and thiamine are present as also some of the trace elements like Mn, B, Zn and Iodine. Thus it has been possible to culture the rice embryos in La Rue's medium. In this medium sucrose or dextrose can serve equally well as the source of carbon and a change of the initial pH from 7 to 5 does not appreciably affect the early growth. Continued growth of rice embryo in artificial media with or without the addition of further growth factors and their survival on transplantation in soil is under investigation.

C.1.4. *Studies of non-differentiated plant tissue:*

- a) *Initiation of non-differentiated tissue in carrot*
 - i) *In vivo experiments.* Attempts were made to produce callus tissue in carrot by the application of β -indole-acetic-acid on cut surfaces of carrot fragments. Sterilised fragments of carrot were surface treated with a thin paste of 3% IAA in lanoline and kept in moist sand in glass covered trays maintained at 30°C and also at 25°C. The fragments were contaminated. Second experiment using sterile moist sand in plugged

test tubes also gave indication of contamination. Owing to the difficulty of maintaining aseptic condition in moist sand, the treated fragments were cultured on 2% sucrose agar and White's nutrient medium where callus tissue formed within three weeks of IAA application.

ii) *In vitro experiments.* Small fragments of carrot 4 to 6 mm. in length. and 2-4 mm. thick, were bored out of the region of cambium ring. For this, only carrots showing well defined circular cambium rings were used. The fragments were washed in sterile distilled water and cultured in White's liquid medium, semi solid White's medium and 2% sucrose agar medium. Some of the fragments were contaminated and a few failed to show any growth and these were discarded. The growing fragments were transferred to fresh media at 7 & 15 days intervals. Callus growth was observed on the cut surface, particularly on the cambium zone after 2nd or 3rd transfers, and this growth continued well for about 4 months, after which there was no appreciable increase in their size. Considering the general appearance of the fragments and the callus growth, White's semi-solid medium (pH 4.6-4.8) was found to be the best of the three used.

However it was observed that the presence of secondary phloem and xylem, which grow at the expense of cambium is rather a hindrance to the development of callus tissue. A new method of obtaining small fragments of carrot tissue of known origin, specially pure cambium and pure primary phloem is being tried at the present.

b) *Crown gall tumour tissue*

i) Primary experiments were concerned with standardising the method of producing actively proliferating crown gall tissues in plants. *Agrobacterium tumefaciens* is the causal agent in tumour production in plants, and naturally occurring gall tissue is a source of this organism. A careful search for plant gall in the Indian Botanical Gardens at Sibpore, and in the surroundings of Calcutta last summer was made without any success. However a gall like growth was obtained on the leaves of *Trewia nudiflora* and a bacteria was isolated from this growth. This bacteria however failed to induce any tumour growth when tested on *Bryophyllum* sunflower and *Vinca rosea* plants. No attempt was therefore made to identify the bacteria.

ii) A culture of *Agrobacterium tumefaciens* was obtained last June, from the type culture collection, of the Indian Agricultural Research Institute, New Delhi. But this was found to be sterile. A fresh culture was obtained in September and this time it was possible to grow the organism satisfactorily in Potato dextrose agar, Nutrient agar, Pot-mannitol agar, Sodium glycocholate agar and Pot. nitrate agar. Of these however, the Potassium nitrate agar medium

(pH 7.0) as used by Riker (1950) was found most satisfactory. The purity of the strain was confirmed.

The gall inducing property of this strain of bacteria was tested on Bryophyllum, sunflower, tomato and periwinkle by single and multiple needle puncture method, and the method was successful in all the plants excepting periwinkle. The observations were confirmed by repeated experimentation. Sunflower is the most responsive host, the tumour appearing in about 15 days after inoculation and tomato (about 22 days) comes next. In Bryophyllum it takes about 30 days for visible tumour to appear, but they were largest in size. The perennial nature of Bryophyllum and the size of the galls makes it a natural choice for further work.

Bacteria was isolated from these gall tissue and tested biologically for gall production and found to be positive.

Attempts are being made to produce gall on Bryophyllum leaves.

iii) Efforts were next directed to obtain bacteria-free tumour tissue suitable for *in vitro* biochemical studies. Kunkel (1941) successfully obtained virus free periwinkle tissue with 'heat treatment'. In his experiment the host parasite complex was subjected to a high temperature for a suitable length of time to kill the causal agent and yet to permit the survival of the host plant itself. Braun (1943) first employed this 'heat treatment' principle to obtain bacteria-free tumour tissue. Riker has recently shown that 3 days exposure of the infected plant to a temp. of 46.5°C and 60-65% relative humidity helps to produce bacteria free tumour tissue.

For our experiment a chamber has been specially designed with proper thermostatic and hygrostatic control to maintain a temperature of 46.5°C and a relative humidity of 60-65%.

Bryophyllum plants were used in these experiments. They were inoculated with fresh culture of *A. tumefaciens* and after inoculation were left in the open air for 4 days for the bacteria to initiate the gall. After this period five out of seven inoculated plants were transferred into the heat treatment chamber and the remaining two were left in open air to serve as control. The treated plants were removed from the chamber one after the other at 24 hour interval and maintained in open air. Steps were taken to ensure adequate moistening of the soil of the plants in the high temperature chamber. All of the heat treated plants excepting those treated for 24 hrs. only, were seriously damaged and failed to recover. Repeated experiments met with same fate. A new method of localised heating to obtain bacteria free tumour tissue is now under consideration.

In the meantime *in vitro* experiments have been conducted to find out the critical lethal temperature for this strain of bacteria. As a result of these experiments it has been established that the bacteria cannot survive even 24 hours at a temperature 46.5°C whereas it can stand 40°C even for 5 days.

Appearance of non-pathogenic strains (perhaps due to suggested mutation) in bacteria surviving heat treatment has been reported and experiments are being carried out with the culture surviving at 40°C to find out if any such effect has been obtained with this strain of bacteria.

Further experiments are being carried out to determine the exact temperature and exposure time lethal to the bacteria.

iv) Similar experiments were done with inoculated carrot fragments to obtain bacteria free tumorous growth in carrot. After the desired period of heat treatment, the fragments were transferred to fresh media and allowed to grow at 25°C . Portions of media in which the fragments were heat treated proved on examination, to be free from living bacteria. The fragments however, were not free from bacteria as was shown by bacterial growth in the media at later incubation period. This treatment also damaged some of the tissue fragments irreversibly. However heat resistance capacity of the carrot tissue seems to be related with the particular type of tissue, as in some cases though, the temperature during the treatment was considerably high, damage to the fragments was negligible. These experiments indicate that though this heat treatment kills the bacteria in the medium, it is not certain whether the bacteria present in the tissue would be killed. No callus growth however was observed in the heat treated fragments. This may indicate that after heat treatment though the fragments were apparently healthy some sort of internal change might have taken place which stood in the way of further development. Further experiments are being carried out.

C.1.5. Effect of the application of β -indole-acetic-acid in different mode and in different concentration on Tomato & Tobacco Plants:

In continuation of the work done last year on this subject, the experiments were conducted this year also.

One variety of tomato and two varieties of tobacco have been used. The seeds were sown in seed pots and after about 45 days, they were transplanted, one in each of a 12" pot containing manured garden soil. Two weeks after transplantation the plants were classified according to their height and vigour and seven groups of approximately the same nature were formed for the different treatments. The seven groups of plants were arranged in the field in a way as to eliminate the influence of border, light, shade, etc. on the groups.

Three different concentrations of IAA (0.005%, 0.01% & 0.02%) were used and they were sprayed on the leaf surface in 3 groups and on the soil around the base of the plant in 3 other groups, the seventh group of plants were untreated and grown as normal control. Each plant was sprayed four times at weekly intervals. Data was maintained regarding their height, number of branches, leaves, time of flowering, flower clusters, fruit setting and fruit ripening, as the case demanded, at regular intervals.

After about 3 months the fruits on the tomato plants were harvested, their fresh weight recorded, and they were analysed for moisture, sugar and vitamin C content. In case of tobacco the harvesting was done at the end of about the same period and height, fresh weight and dry weight of the stem and root, and also the number, area and fresh weight of the leaves were noted. The leaves were further analysed for moisture and nicotine content,

It was found that in case of tomato, the vegetative growth as determined by final height, number of leaves, number of branches, etc., was not influenced appreciably by the hormone treatment. But a definite trend in the rate of weekly increase in length of the plant during the period of hormone treatment was observed. The treated plants attain the maximum rate of growth somewhat earlier than the untreated control. The effect being more pronounced when the hormone was sprayed on leaves. However this rate gradually declines towards the normal with the cessation of hormone application. An exception to this was observed in the groups where the concentration of IAA used was 0.02%. Here the maximum rate was attained much too early and persisted for some time.

Hormone treatment does not seem to affect in any way the time of flowering, number of flower clusters or the number of flowers bloomed. But with 0.02 % IAA, in both the groups, there was a definite increase in the total yield of fruits as regards their total number and total fresh weight. There was however little difference in the moisture, sugar and vitamin C contents of the fruits. These results are summarised in Tables I, II and III.

In tobacco experiment the general condition of one variety, White Burley was comparatively poor than the variety Harrison Special.

Here also, IAA in a conc. of 0.02% seemed to have produced an increased yield of tobacco leaves. This is due to an increased number of leaves and not due to an increase in the size or fresh weight of individual leaves. At this concentration, the mode of application of the hormone does not seem to be very critical (Table IV).

TABLE I.
DATA SHOWING WEEKLY HEIGHT INCREMENTS IN TOMATO PLANTS

	Average initial height per plant 10-11-52	Weekly increments in height in cms.									Average final height per plant 19-1-53
		I	II	III	IV	V	VI	VII	VIII	IX	
Sprayings :—					1st	2nd	3rd	4th			
.005% IAA on leaf	7.4	2.7	6.6	13.2	14.2	19.9	17.0	11.1	9.8	0.9	102.1
.005% „ „ soil	7.2	3.4	7.2	9.7	14.0	18.7	19.3	12.4	12.1	1.8	105.6
.01 % „ „ leaf	6.6	2.3	7.6	10.8	9.9	19.6	15.5	11.5	11.7	1.7	97.2
.01 % „ „ soil	5.6	2.5	5.8	9.0	13.9	18.7	20.2	15.0	11.7	0.8	130.2
.02 % „ „ leaf	6.5	0.1	7.5	10.0	12.0	17.6	17.5	13.5	15.6	2.1	102.5
.02 % „ „ soil	6.5	1.9	6.8	8.6	14.1	17.0	17.3	13.5	11.9	0.4	99.1
Untreated Control	6.6	2.3	7.7	9.9	17.7	14.0	11.0	24.2	11.5	0.0	103.7

TABLE II.
DATA OF VEGETATIVE GROWTH IN TOMATO PLANTS

Treatments		Number of plants in the treatment	Average final height per plant cms.	Average number of leaves on main stem	Average number of branches longer than 10 cms.	Total length of branches excluding main short	Average number of full grown leaves per plant
IAA. concentration	Mode of application						
.005%	on leaf	9	102.1	19.4	3.0	85.4	33.4
	on soil	8	105.6	17.5	3.7	99.1	35.7
.01%	on leaf	9	97.2	17.7	3.4	80.7	35.0
	on soil	10	103.2	17.3	3.7	83.5	33.3
.02%	on leaf	10	102.5	15.5	2.8	75.9	31.3
	on soil	10	99.1	17.0	3.8	98.5	37.3
Untreated control		9	103.7	17.1	3.9	95.7	34.4

TABLE III
DATA OF FLOWERING AND FRUITING IN TOMATO PLANTS

Treatments		Average number of flower clusters	Total number of fruits	Total fresh wt. of fruits in gms.	Average fresh wt. of a single fruit	Free sugar content; dextrose as % fresh wt.	Ascorbic acid content as mgm/100 gm. fresh wt.
SAA-Conc.n.	Mode of application						
.005%	on leaf	5.9	45	2430.4	54.0	2.72	36.24
	on soil	5.6	50	2490.6	49.8	4.30	29.35
.01%	on leaf	5.7	46	2359.6	51.3	3.0	34.27
	on soil	5.3	50	2601.6	54.0	4.11	27.69
.02%	on leaf	7.6	61	2907.2	47.7	4.31	30.03
	on soil	7.7	60	3149.9	52.5	3.50	34.34
Untreated Control		6.8	47	2485.0	52.8	3.88	31.63

TABLE IV
YIELD DATA OF TOBACCO LEAVES

Var. Harrison's Special			Treatments	Var. White Burley		
Average leaf number	Average leaf-area sq. inches	Average fresh wt. of leaves gms.		Average leaf number	Average leaf-area sq. inches	Average fresh wt. of leaves gms.
19.3	456.3	112.9	.005% IAA on leaf	13.2	365.0	93.8
19.5	429.0	104.3	.005% IAA on soil	17.0	422.0	106.4
20.7	585.0	147.3	.01 % IAA on leaf	15.3	313.0	81.3
19.7	484.2	113.4	.01 % IAA on soil	15.5	382.0	101.2
21.6	609.4	153.2	.02 % IAA on leaf	14.6	303.5	79.8
22.3	656.1	153.6	.02 % IAA on soil	16.0	302.0	80.9
20.0	530.4	124.5	Untreated Control	16.1	366.1	94.7

Hormone treatment however does not seem to affect the moisture or nicotine content of the leaves.

The results given in the Tables have yet to be analysed statistically to make final conclusion on the experiments.

C.1.6. Application of C^{14} as tracer in photosynthesis:

An apparatus has been constructed for studying the photosynthesis of detached leaves with radio active carbon dioxide (vide A.5.1). The problem is to detect the sequence of photosynthetic compound formation in the plant tissue. This involves the isolation of different photosynthetic products by micro-chromatographic methods which has been proposed to be accomplished in collaboration with the Chemical laboratory. The apparatus has been tested by preliminary experiments using ordinary barium carbonate and artificial light. In tobacco and balsam appreciable amount of starch formation has been detected by iodine method of testing after twenty-four hours exposure on starved leaves.

C.1.7. Study of expulsion of sap from pulvinus of Mimosa pudica during contraction:

It has been reported previously that a device has been made by which quantitative determination of the expulsion of sap during the contraction of the Mimosa pulvinus under stimulation, has been possible. The experiment is being continued to detect the preferential path through which the expulsion of sap from the contracted pulvinus occurs.

C.1.8. Study of respiration in pulvini of M. pudica during contraction:

In a previous work it has been shown that the normal respiration rate of the pulsating leaf of *Desmodium* undergoes periodic modulations indicating differential dissipation of energy with the rise and fall of the leaf. The periodic modulations of respiration could not, however, be correlated with the rise and fall of the pulsating leaf. In order to understand how the change of respiration is correlated with the rise and fall of the leaf fresh investigation has been started. Instead of quick moving autonomous *Desmodium* the investigation is being carried out with the leaf of *M. pudica* in which the movement of the leaf can be controlled by stimulation from outside.

C.1.9. Physiological effect of irradiation:

The effect of irradiations, by both X-rays and Ultraviolet rays, on the growth and physiology of flowering was studied with two varieties of rice (*Oryza sativa* L.). In three sets of experiments, dry seeds and three week old seedlings were subjected to different doses of X-ray; and the consequent physiological effect as manifest in germination, general growth and reproductive phases was recorded, in laboratory, and field experiments.

In all cases the number of plants surviving and reaching maturity was comparatively poor and a critical analysis of the data to establish whether the variations were of any significance was not possible. However the results obtained indicated the following trends:

In cases of dry seeds. (i) The irradiation did not affect the length of the resulting plants within the period of experiments;

(ii) Though there was no early initiation of flowering, percentage of tillering and flowering increased in plants from treated seeds.

In cases of a soaked and sprouted seeds.

(i) Higher doses of X-ray inhibited the growth of the resulting plants, both in number and length, the effect being more pronounced with increasing dose of irradiation;

(ii) Irradiation resulted in an increase in the percentage of average number of vegetative and reproductive tillers and also an early initiation of flowering in the plants.

Whereas in the experiments with the three week old seedlings none of the plants, including the untreated controls survived in spite of every possible care; this made any conclusion impossible.

In some experiments with ultraviolet rays (source: Philips germicidal lamps, 2000 Å—3000Å, with maximal at 2650Å) it was observed that jute seedlings could not stand the irradiation at all, when applied

for 10 mins. from a distance of 20 cm., whereas rice seedlings of the same age were not at all affected under the same conditions. Further it was observed that a variation in the period of irradiation (upto a maximum of 10 minutes) and also cumulative doses of such irradiation given at 10 days interval, did not affect the subsequent growth of the seedlings even after 62 days. The plants including the untreated controls however did not survive further to make any other physiological observation possible.

C.2. Plant Breeding and Cytogenetics

C.2.1. Cotton Breeding Investigation:

This is a scheme financed by the Government of West Bengal for evolving long stapled cotton types, suitable for cultivation in the deltaic areas of West Bengal and is in the eighth year of investigation, during the year under report.

The season was fairly favourable for the growth of cotton, excepting for the droughty conditions which prevailed during the earlier part of this year. No irrigation could be given during this period, due to the break-down of our irrigation pump. Even then, the plants were quite healthy and gave a good yield; the latter would have been better had there been the usual rains or irrigation facilities.

During the year, detailed studies were made of the 401 strains (28 parent types and 308 hybrids from the F_2 to the F_8 generations, the rest being reciprocal cyclic and multiple crosses from the F_8 to the F_5 generations) which were allowed to continue in the field for the second year in succession. Similar experiments were conducted during the previous season also the details of which had been included in the last report. In general it was noticed that the yield of the plants during the first quarter of the second year was greater than for the same period in the year. Thereafter, the yield of these plants left in the field for the second year decreased steadily and by the end of that season there were hardly any pickings from several of the strains. The quality of the lint, the incidence of pests and diseases etc, were similar to those reported during the previous year. Hence it is not advisable to leave the plants in the field during the second year also for reasons stated on page 2, para 1, of the previous years report.

The 38 strains, which were found to be better under the conditions at Falta, together with Sea-Island type and parbhani-American (recommended for cultivation by the Government of West Bengal) were

freshly sown in four replications and their lint lengths, ginning percentages and the number of days required for the first flush, the average yield per plant and the yield of the best plant, were collected and are listed in Table 1.

The readings given for lint length and ginning percentages in the above table were the average taken from a number of seeds. These figures do not differ significantly from those of the previous year hence it may be assumed that they, including the hybrids, are stable from the practical point of view.

It will also be noticed that the individual plants in some of the strains gave a good yield, the maximum being 41 bolls in C-II-2. This type gave an average yield of 10.6 bolls per plant. As against this, the parbhani-American type gave a maximum yield of 11 bolls only and an average of 5.2, which is very low. In this connection it may be pointed out that we are giving a spacing of 9" between plants as against 2.6" given at Tripua, which partly accounts for our lower yields. Also, we had been growing cotton in the same field year after year, without rotation or manure, which has also tended to lower the yields.

The Sea-Island cotton, which has lint length of 62.5 mm. under its natural environmental conditions and which was rather difficult to grow under our environmental conditions, was successfully grown this year under shades. Hence this will prove to be a valuable type which can be grown in gardens or plantations, under the shades of trees, thereby providing a subsidiary income. Moreover its fibers are very fine and long. This gave a lint length of 47.5 mm. a ginning percentage of 27.21 and required only 90 days for the first flush. The parbhani-American listed in the above table is one of the inferior types with a lint length of 30.5 mm. and a ginning percentage of 32.55 only and it took 125 days to give the first flush. Hence this is not only the last in flowering when compared with the other strains listed in Table I, but its lint length and ginning percentages are also lower than most of the strains listed.

During the year, due to the droughty conditions which prevailed during the sowing period, the sowing was delayed with the result that the flowering was also delayed. But the relative earliness was being maintained.

Irradiation experiments were continued during the year under report, as this is a quick and fruitful source for inducing mutations with economic importance, and the results are included in Table II.

Seven varieties were irradiated, comprising of five parent types and two hybrids, each exposed to soft X-rays for 5, 6, 7, 8, and 9 m.a. hrs. respectively. The varieties and hybrids selected were early flowering, with good lint lengths, but medium yields.

TABLE I

Type	Serial No.	Name	Period required for 1st. flush in No. of days	Lint Length in mm.	Ginning percentage	Average No. of bolls per plant	Maximum number of bolls collected from a single plant
Parent:	1.	C-II-2	122	29.0	32.67	10.6	41
	2.	K-I	118	30.5	33.33	8.3	14
	3.	7682	87	34.0	35.82	8.6	18
	4.	7682-18B	85	36.0	35.33	5.1	11
	5.	7682-14-E2	85	35.0	35.26	3.5	19
	6.	7682-21 × (CO4 × (SG × S1) × 4456	104	33.0	35.65	3.2	13
	7.	7733D32e × (CO3 × CO4)R.A. × SG. A.	92	34.0	34.56	5.1	16
	8.	5286 BUI	92	35.0	35.76	6.3	15
	9.	7625-1	100	31.5	37.14	6.9	18
	10.	7733-8	99	34.0	35.29	7.0	17
	11.	6113F2	92	33.5	35.60	8.6	21
	12.	7727G3	97	36.0	35.12	8.1	18
	13.	3097C6	96	34.0	36.66	9.4	31
	14.	LSS	94	32.0	36.83	7.7	20
	15.	4F	93	34.5	34.65	5.1	13
	16.	4463	97	31.5	34.02	5.8	21
	17.	920	98	32.0	35.48	6.3	16
	18.	CO4	94	33.0	35.26	9.3	25
	19.	CO4-B4O-21	90	34.5	38.55	4.3	18
	20.	CO3	92	33.0	35.67	3.5	19
	21.	CO3-41	103	34.0	35.84	5.6	11
	22.	CO2	91	34.0	34.93	6.2	14
	23.	Parbhani American	125	30.5	32.55	5.2	11
	24.	Sea Island	90	47.5	27.21	2.5	6
F9	1.	LSS ix 4F	83	34.5	25.00	7.5	19
	2.	920.IX. 4F	85	34.5	36.06	5.1	27
	3.	920.IX. CO2	96	32.0	33.89	9.1	22
	4.	CO4.IX. LSS	85	32.5	36.47	2.7	15
	5.	CO2. IX. 289F. 43	118	35.0	35.48	7.6	23
	6.	CO2. IX.4F	76	33.5	37.2	5.1	21
F8	1.	7625-1. VIII LSS	96	33.5	34.06	9.2	20
	2.	7727G3. VII. 5286 BUI	96	34.0	34.78	7.1	14
	1.	CO2. VII. 4F	85	34.5	35.29	8.5	28
	1.	7733-8. VI.5286 BUI	89	32.5	34.48	6.0	13
	2.	7733-8. VI. 7625-1	87	33.5	35.71	8.0	16
	3.	7733-8. VI. 7727G3	121	33.0	35.00	6.3	14
	4.	6113F2. VI. LSS	91	33.5	33.01	10.0	24
	5.	7733-8. VI. 289F 124	98	32.0	35.44	5.5	16
	1.	(CO3 × 5286BUI) VII. 920	114	33.5	35.45	9.1	28
	2.	(CO2 × 4463). VII. (CO4-LSS)	92	33.5	32.67	6.0	17

TABLE II

Type	Serial No.	Name	Treatment	Lint length in mm.	Difference with control	Ginning percentage		Average No. of bolls per plant		Maximum number of bolls collected from a single plant
						of the types	difference with control	No. of bolls per plant	Difference with control	
Parent	1.	CO2	Control	33.5	—	34.20	—	14.71	—	27
			5 m.a.H.	33.5	± 0	37.62	+ 3.42	34.00	+ 19.29	34
			6 "	33.0	— 0.5	40.11	+ 5.91	15.17	+ 0.46	77
			7 "	32.5	— 1.0	37.32	+ 3.12	23.50	+ 8.79	51
			8 "	32.5	— 1.0	39.18	+ 4.98	20.94	+ 6.23	56
			9 "	32.5	— 1.0	38.53	+ 4.33	27.79	+ 13.08	52
	2.	4F	Control	34.9	—	36.00	—	19.18	—	33
			5 m.a.H.	34.5	+ 0.5	37.90	+ 1.20	13.36	— 5.92	65
			6 "	33.5	— 0.5	39.13	+ 3.13	11.88	— 7.30	32
			7 "	33.5	— 0.5	36.50	+ 0.50	15.89	— 3.29	104
			8 "	34.0	± 0	37.70	+ 1.70	14.00	— 5.18	88
			9 "	33.5	— 0.5	37.66	+ 1.66	12.15	— 7.03	24
	3.	920	Control	31.5	—	35.20	—	8.26	—	22
			5 m.a.H.	31.5	± 0	36.66	+ 1.36	9.00	+ 0.74	31
			6 "	30.5	— 1.0	37.87	+ 2.67	7.75	— 0.51	22
			7 "	32.0	+ 0.5	36.92	+ 1.72	7.42	— 0.84	25
			8 "	30.5	— 1.0	26.84	+ 1.64	11.00	+ 2.74	46
			9 "	31.5	± 0	35.48	+ 0.28	13.17	+ 4.91	66
	4.	7682-14-F2	Control	36.0	—	35.36	—	6.82	—	30
			5 m.a.H.	36.0	± 0	35.55	+ 0.19	11.00	+ 4.18	26
			6 "	34.5	— 1.5	37.73	+ 2.37	8.50	+ 1.68	15
			7 "	35.5	— 0.5	34.44	— 1.92	13.54	+ 6.72	36
			8 "	34.5	— 1.5	37.50	+ 2.14	10.68	+ 3.86	29
			9 "	35.0	— 1.0	37.03	+ 1.67	9.67	+ 2.85	15
	5.	7682-18B	Control	35.5	—	36.25	—	8.10	—	18
			5 m.a.H.	35.5	± 0	38.94	+ 1.69	8.53	+ 0.43	22
			6 "	34.5	— 1.0	36.94	+ 0.69	12.95	+ 4.85	32
			7 "	35.0	— 0.5	36.36	+ 0.11	9.96	+ 1.86	47
			8 "	34.5	— 1.0	36.73	+ 0.48	13.10	+ 5.00	42
			9 "	34.4	— 1.5	37.91	+ 1.66	10.61	+ 2.51	26
F9	1.	CO2-4F	Control	33.5	—	37.16	—	13.65	—	49
			5 m.a.H.	33.5	± 0	38.00	+ 0.84	19.50	+ 5.85	57
			6 "	34.0	+ 0.5	37.61	+ 0.45	19.83	+ 5.78	89
			7 "	32.5	— 1.0	37.96	+ 0.83	10.25	— 3.40	57
			8 "	34.0	+ 0.5	37.78	+ 0.22	12.03	— 1.62	54
			9 "	34.0	+ 0.5	36.47	— 0.69	15.90	+ 1.25	46
	2.	920.IX.4F	Control	31.5	—	36.43	—	8.81	—	40
			5 m.a.H.	31.5	± 0	37.87	+ 1.44	4.86	— 3.95	48
			6 "	30.5	+ 0.5	37.64	+ 1.21	8.38	— 0.43	55
			7 "	32.0	— 1.0	34.84	— 1.59	5.68	— 3.13	48
			8 "	30.5	+ 0.5	38.88	+ 2.45	8.14	— 0.67	57
			9 "	31.5	+ 0.5	35.13	— 1.30	6.26	— 1.55	42

An analysis of the above table shows that there is very little difference in the lint lengths between the control and the irradiated types. In many, they are lower in the X-radiated progenies, but the differences are not significant. But the ginning percentages are greater in the treated types than in the controls and in CO₂ this difference is most marked and significant. For example, in the 6 m.a. hrs. treatment of CO₂, the increase in ginning percentage is about 17%, over the control. If these continue to behave in the same manner in the subsequent generations, it will be a good achievement. When the yield of the best plant is considered, the differences appear to be even more marked. In CO₂, in which the best plant in the control had only 27 bolls, one plant in the 6 m.a. hrs. treatment gave 77 bolls. Also the best plants in all the other treatments gave much higher yields than the control. In type 4F, while the control had only 33 bolls, one plant in the 7 m.a. hrs. treatment had 104 bolls. In type 920 also, these figures are 22 in the control, as against 66 in the 9 m.a. hrs. treatment. In all the above cases the *increase in yields is 3 times over the control*. The other types listed also, registered increased yields in the X-radiated progenies, which is very much appreciable in some of the treatments, although not as much as in the previous cases. These are very interesting and it has now to be studied how they behave in the succeeding generations. When the average yield is taken into account in five of the types, they are higher than in the controls, either in all, or the majority of treatments, while in the remaining two types they are lower than the controls. In this respect also, CO₂ gave the best results and in one treatment, viz. 5 m.a. hrs., *the increase in yield is 2 times over the control*.

The hybrids derived by crossing the tree cotton (as the male parent) with the economic hybrid strains evolved by us, such as 920×4F(F₄) 920×LSS(F₄) (as female parents) were studied in their F₄ generations during the year under review. The vegetative characters as well as the nature and the arrangement of the seeds in the F₄ generations were more like their female parents and that they were progressively tending to the maternal characteristics in the succeeding generations. But the shape and size of the bolls were like that of the tree cotton viz. large and tapering. During the F₂ and F₃ generations these flowered late like the tree cotton, but in the F₄, the flowering is much earlier. Although these hybrids gave a good yield, their fibres were coarse and attempts were made to back cross these with the female parents to improve the fiber quality. Out of the progenies, the lint of one appeared to be better.

The behaviour of fuzzless hybrids of CO₂×4F, 920×4F and LSS×4F, which were in the F₉ generation during the year under report were studied. Gradations from full fuzzless to nearly full fuzzy seeds were isolated from the progenies and studied.

C.2.2. Jute:

C.2.2.1 Irradiation experiments.

(a) Sowing season of 1952.

Dry seeds of Chinsura Green, R-26 and Tall Mutant (T.M.) of *Corchorus olitorius* L. and D 154 and D 386 of *C. capsularis* L., were irradiated for 80 and 125 m.a. hrs, both being new high doses not attempted earlier. In addition to the freshly irradiated seeds, (i) X_2 seeds of all the promising X_1 s of 1951 in all the above mentioned five types, (ii) early flowering types, (iii) bifurcation and branching types, and (iv) morphologically abnormal plants, were also sown in the second week of April in replicated plots with a spacing of 1' between rows and 6" between plants.

Soon after sowing, the fields were artificially flooded to a depth of about 4" when it was found that the germination was good.

HEIGHTS AND BASAL DIAMETERS.

Table (3) gives the heights and basal diameters of the best plants in the control as well as in freshly irradiated and X_2 progenies without any further treatment, in all the 5 types of jute included here.

TABLE 3

Variety and Treatment				Plant Height	Basal Diameter
Tall Mutant (Generation)—Control				19'4"	1.1"
"	X_2	28 m.a.hrs.	"	17'10"	1.0"
"	X_2	36	"	17'5"	1.0"
"	X_2	42	"	18'10"	1.1"
"	X_2	48	"	17'9"	1.0"
"	X_2	60	"	18'4"	1.0"
"	X_1	80	"	19'4"	1.1"
"	X_1	125	"	18'8"	1.1"
R — 26. (Generation)—Control				17'3"	1.0"
"	X_2	28 m.a.hrs.	"	18'8"	1.1"
"	X_2	36	"	18'3"	1.2"
"	X_2	42	"	18'4"	1.1"
"	X_2	48	"	18'10"	1.1"
"	X_2	60	"	19'5"	1.2"
"	X_1	80	"	18'3"	1.1"
"	X_1	125	"	19'3"	1.1"
Chinsura Green (Generation) Control				17'5"	1.1"
"	X_2	28 m.a.hrs.	"	18'8"	1.1"
"	X_2	36	"	20'4"	1.2"
"	X_2	42	"	19'8"	1.2"
"	X_2	48	"	16'2"	1.0"
"	X_2	60	"	18'7"	1.0"
"	X_1	80	"	19'2"	1.2"
"	X_1	125	"	19'10"	1.2"

Table 3 (contd.)

D 154	(Generation)	Control	14'7"	1.1"
"	X ₂	28 m.a.hrs.	12'8"	0.9"
"	X ₂	36 "	14'4"	1.1"
"	X ₂	42 "	14'2"	1.1"
"	X ₂	48 "	14'0"	1.1"
"	X ₂	60 "	13'10"	1.1"
"	X ₁	80 "	13'10"	1.1"
"	X ₁	125 "	13'9"	1.0"
D 386	(Generation)	Control	14'9"	1.2"
"	X ₂	28 m.a.hrs.	13'8"	1.0"
"	X ₂	36 "	13'10"	1.2"
"	X ₂	42 "	12'8"	0.9"
"	X ₂	48 "	13'9"	1.1"
"	X ₂	60 "	13'7"	1.0"
"	X ₁	80 "	13'10"	1.1"
"	X ₁	125 "	13'10"	1.1"

From the above table it will be seen that increased heights have been recorded in the treatments of R-26 and Chinsura Green. Unlike previous year, T.M. did not show any increase in height or basal diameter after irradiation. It appears that in the case of R-26, marked increase in plant heights has been noted in the treated population (X₁) over the control; X₂ progenies also exhibited greater heights with a maximum increase of 2'2" over the control as seen in 60 m.a.hrs. treatment of X₁. A striking similarity has also been recorded in the case of Chinsura Green, where, excepting in one of the X₂ progenies i.e., 48 m.a.hrs. of X₁, all were found to be promising, with a maximum increase of 2'11" over the control as in the case of 36 m.a.hrs. of X₁. Here again plant heights and basal diameters increased by 1'9" and 0.1" and 2'5" and 0.1" following fresh irradiations with 80 m.a.hrs. and 125 m.a.hrs. respectively.

Unlike *olitorius* types, no increase in the heights or basal diameters of the plants has been recorded in the *capsularis* types. Probably this is due to the fact that *capsularis* types require greater doses than the *olitorius* types. These have been given in 1953 season.

Here it may be mentioned that the best plant in T.M. is taller by 2'1" than the control (R-26); the difference in basal diameter being negligible (cf. Table 3).

Table 4 gives the average heights and basal diameters of 50 of the tallest plants in T.M. and control (R-26).

TABLE 4

Variety	Plant Height	Basal Diameter
R-26 (Control)	13'9"	0.7"
Tall Mutant	16'5"	0.9"

It may be noted that there is *difference of 2'8" in heights and 0'2" in basal diameter* between T.M. and R-26.

During the period under report, an analysis of flowering period (time taken from the first plant to the last plant to flower in the population) of the controls and various treatments (X_1 & X_2) of all the types, was made and are tabulated in Table 5.

TABLE 5

Variety and Treatment			Flowering Period (in days)
Tall Mutant (generation) Control			110 days
"	X_2	28 m.a.hrs.	28 "
"	X_2	36 "	112 "
"	X_2	42 "	27 "
"	X_2	48 "	33 "
"	X_2	60 "	28 "
"	X_1	80 "	27 "
"	X_1	125 "	28 "
R-26 (generation) Control			102 days
"	X_2	28 m.a.hrs.	73 "
"	X_2	36 "	85 "
"	X_2	42 "	107 "
"	X_2	48 "	110 "
"	X_2	60 "	80 "
"	X_1	80 "	84 "
"	X_1	125 "	79 "
Chinsura Green (generation) Control			95 days
"	X_2	28 m.a.hrs.	97 "
"	X_2	36 "	97 "
"	X_2	42 "	92 "
"	X_2	48 "	99 "
"	X_2	60 "	98 "
"	X_1	80 "	91 "
"	X_1	125 "	92 "
D 154 (generation) Control			42 days
"	X_2	28 m.a.hrs.	27 "
"	X_2	36 "	29 "
"	X_2	42 "	30 "
"	X_2	48 "	26 "
"	X_2	60 "	32 "
"	X_1	80 "	33 "
"	X_1	125 "	31 "
D 386 (generation) Control			42 days
"	X_2	28 m.a.hrs.	27 "
"	X_2	36 "	28 "
"	X_2	38 "	28 "
"	X_2	48 "	27 "
"	X_2	60 "	25 "
"	X_1	80 "	34 "
"	X_1	125 "	34 "

It will be seen from the above table that in all the types, this time for flowering is always higher in the controls, while in various fresh treatments the period is much lesser. For example, in T.M. *while the control take 110 days, the treated population (X_1) take only 27 and 28 days.* Excepting one X_2 population i.e., 36 m.a.hrs. of X_1 , all X_2 individuals flowered earlier than the control and hence all had shorter flowering period. In R-26 also, only two treated varieties of X_2 populations i.e., 42 and 48 m.a.hrs. of X_1 s flowered late and thereby made the flowering period longer by 5 and 8 days respectively over the control. In Chinsura Green, there is very little difference.

In the *capsularis* types, the two varieties behave more or less in a similar manner. While the control population of both the varieties finished their flowering in 42 days, *all the treated population had shorter flowering period and among them the population which was considered to be late in flowering period was even earlier by 8 days over the control.*

It is yet to be seen, whether by repeated selection of early maturing types from the population of low flowering period, it is possible to have progenies which will flower more or less at the same time or as near to each other. If so, this will be very good as all the plants will mature nearly at the same time.

During the season, selections of some promising *early* types, made from the progenies of Tall Mutant in the year 1950 and carried forward without any further treatment, fared creditably and Table 6 gives a comparative account of the performances of these selections 1950, 1951 and 1952 seasons.

From Table 6 it will be seen that unlike previous year, the period under review was quite favourable so far the early flowering types of T.M. are concerned. *All of them flowered much earlier than the original selection.* It may be pointed out that in the previous season, only one selection i.e., 32/69(50) out of three in T.M. flowered earlier by 11 days while in the year under report all the three selections, i.e., 32/37(50), 32/69(50) and 29/30(50) *flowered earlier by 14, 10 and 13 days and 5, 21 and 7 days earlier* when compared with those of 1951 and 1950 respectively. It is interesting to note that *as selections are made from year to year the plant not only flower still earlier, but maintains their heights and basal diameters* (cf. Table 6).

The behaviour of other selections for earliness in flowering (obtained after X-irradiation) in other varieties of jute, made during the season 1947-51 and carried forward without any further treatment was again

TABLE 6

COMPARATIVE RESULTS OF THE SEASONS 1950, 1951 AND 1952, OF THE PERFORMANCES OF THE PROMISING EARLY TYPES SELECTED FROM THE PROGENIES OF TALL MUTANT IN THE YEAR 1950 AND CARRIED FORWARD WITHOUT ANY FURTHER TREATMENT

(Average behaviour of the Tall Mutant is given in Table 2 and maximum in Table 1).

1950					1951					1952				
Variety	Selection No.	Plant height	Basal dia-meter	Time taken for 1st flowering	Variety	Selection No.	Plant height	Basal dia-meter	Time taken for 1st flowering	Variety	Selection No.	Plant height	Basal dia-meter	Time taken for 1st flowering
Tall Mutant 32/37(50)		14'3"	0.8"	42 days	Tall Mutant 32/37(50)		12'5"	0.6"	51 days	Tall Mutant 32/37(50)		14'3"	0.8"	37 days
Tall Mutant 32/69(50)		12'8"	0.6"	59 days	Tall Mutant 32/69(50)		13'2"	0.8"	48 days	Tall Mutant 32/69(50)		14'2"	0.7"	38 days
Tall Mutant 29/30(50)		13'0"	0.8"	43 days	Tall Mutant 29/30(50)		13'10"	1.0"	49 days	Tall Mutant 29/30(50)		11'3"	0.6"	36 days

studied. A comparative result of the seasons 1951 and 1952 regarding the performances of some of the promising types are included in Table 7.

TABLE 7

COMPARATIVE RESULTS OF THE SEASONS 1951 AND 1952, REGARDING THE PERFORMANCES OF THE PROMISING EARLY TYPES SELECTED DURING THE SEASONS 1947, 48, 49, 50 AND 51 AND CARRIED FORWARD WITHOUT ANY FURTHER TREATMENT ALONG WITH THEIR CONTROLS

Selection No.		Time taken for 1st flowering	
		1951	1952
C. G.	Control	52 days	54 days
	29/97 (47)	50 "	43 "
	26/93 (47)	52 "	51 "
	28/4 (47)	51 "	43 "
	61/1 (47)	82 "	55 "
	30/4 (51)	54 "	52 "
R-26	Control	54 days	56 days
	24/6 (47)	50 "	44 "
T. M.	Control	50 days	52 days
	21/21 (48)	45 "	34 "
	32/37 (50)	51 "	37 "
	29/30 (50)	49 "	36 "
	32/69 (50)	48 "	38 "

Thus it appears from the above table that many of these selections maintained the character for earliness in flowering, some of them showing improved performances.

It has already been pointed out in this report, that X_2 progenies, specially those of *olitorius* types gave satisfactory results when plant heights and basal diameters were taken into consideration. During the year under report, two important aspects of flowering behaviour (i) time taken for the first plant to flower in any variety and/or treatment, and (ii) time taken to flower by the entire population, were noted in control and X_2 progenies of all the materials, here studied. When these details of X_2 s were compared with those of X_1 s, it was found that during the season, flowering started later in T.M., D 154 and in D 386. So time taken for the first plants to flower was more than those in X_1 s. But as soon as flowering had started, it finished quicker than in the previous season i.e., in X_1 generation and hence the flowering period was found to be considerably shorter than that of X_1 generation of the same treatments. In the remaining two varieties i.e., in R-26 and in C.G., the flowering period was found to be greater in X_2 generation than that of X_1 s, while a few plants of X_2 progenies from the same treatment as that of X_1 s flowered earlier than the previous year (X_1 generation).

Shorter flowering period in X_2 progenies is definitely significant and is of some value. But it is too early to predict their future performances in subsequent generations. Arrangements have already been made to grow X_3 progenies without any further treatment, as for successful isolation of vital mutants from segregating X_1 progenies, the most productive and promising X_2 & X_3 individuals are to be selected.

An analysis of pollen grain sterility from a study of their shape, size and contents, was made in the controls and fresh irradiations of all the types of jute included here.

It was noticed that there is an increase in pollen grain sterility with increase in doses, the difference in percentage of sterility of pollen grains between control and treated population was however low, showing thereby that the cells taking part in the formation of reproductive cells were less affected by X-rays, during the year under report.

(b) *Other morphological peculiarities:*

In the X_2 generation of 28 m.a.hrs. treatment of R. 26, ten plants were isolated early in the season which were quite different in their habit when compared with other individuals from the same progeny and also from the normal ones. The plants were characterized by their stunted growth, peculiarly segmented leaves and with a deep scarlet colour resembling that of *Tall mutant* developing in the stems and ultimately spreading over the leaves, where patches of scarlet and pink colour were noticed even in young stages.

The leaves of these plants differ from the normal, by the absence of a complete leaf blade, resulting in a change of shape of the leaves from broadly lanceolate to more or less palmately segmented. In all cases, the segments of lamina were found to be missing, resulting in the midrib being extended to its full length and at places it may bear the segments of wing or may remain even without them. No normal leaves were noticed in these plants.

All the plants died prematurely and more or less at the same time without bearing any flowers. Cytological observation on root tip chromosomes of such plants revealed the diploid chromosome number as $2n=14$.

It was stated in earlier reports that in D 154 of *C. capsularis*, one plant was isolated after X-irradiation which was characterized by narrow leaf blades, dwarfish growth and poor seed setting. Every year very limited number of viable seeds were formed. In the X_4 generation, in

1952, twelve plants were selected which exhibited poor vegetative growth, with the peculiar leaf morphology as stated above. These plants flowered in the usual time but seed setting was found to be lower than X_3 generation and it may be pointed out that as selections are made every year without any further treatment, the development of good seeds is becoming rarer. The fruits formed were of varying sizes, some of them being either unusually large or unusually small and without well developed seeds.

In the above, at metaphase I, 7 bivalents were clearly seen. Occasionally one or two pairs of chromosomes were found to be free at distance, when others are paired and with chiasma. Early separation of one or two bivalents were observed in some of the pollen mother cells. Besides the normal segregation of 7 univalents at the poles during anaphase I, a number of mother cells were found exhibiting non-disjunction of one or two bivalents, which theoretically would have led to the production of nuclei with $n+1$ and $n-1$ chromosomes at second division. But as no such cases were noted in the second division, it may be explained that the nuclei with deficient chromosomes as well as those with an excess, did not survive and were lost. Cytological observations revealed stickiness in chromosome leading to a very close association of bivalents and in extreme cases clumping of chromosomes was also noticed. The chromosomes were found to tend to be shorter even at full metaphase than in controls. The phenomenon of cytomixis was found to take place in nearly all loculi of stamens studied. A high percentage of pollen grain sterility was also recorded.

(c) *Cytological studies of early flowering types.*

A few of the promising early flowering types representing selections from T.M., C. G. and R. 26 of *C. olitorius* constituted the materials for this study.

Although a number of standard fixatives were tried to bring out the details of the chromosome morphology, no clear difference among the types of chromosomes in these varieties were noticed.

The behaviour of the chromosomes during meiosis in almost all the cases has been found to be fairly normal. Certain irregularities like non-disjunction, univalent formation, as described later, occur in all the varieties. Fourteen chromosomes of these varieties pair normally during meiosis. In diakinesis, considerable condensation of the paired chromosomes take place along with the terminalization of the chiasmata. In a number of mother cells the individual units of one or two bivalents were found to lie a short distance apart, when other members are paired and with chiasmata probably due to asynapsis. The percentage of such open bivalents, in contrast to the closed

ones, has sometimes been found to be greater. In addition to 7 bivalents during the first division, some of the mother cells have been found to possess one extra chromosome. This extra chromosome, together with a normal pair, forms a trivalent. Though the separation of bivalents during anaphase I and their subsequent movement to the poles have been found to be slightly irregular, in general however the migration of 7 chromosomes to either poles has been seen in most of the mother cells. It is interesting to note that the phenomenon of non-disjunction has been manifested in all the varieties here investigated.

Laggards usually univalents, have also been noticed in a small percentage of mother cells. The second meiotic division is fairly normal.

C.2.2.2 Saline water experiments.

The seeds were sown on 27.4.52 and the harvesting was from 15.11.52 to 25.11.52.

The heights and basal diameters of the plants were measured during harvesting from fifty plants of each plot, selected at random and the average calculated from those data, were taken as the average for that type in each treatment and control. Due to scarcity of land, only one plot could be taken for each treatment. Each of those plots measured $30' \times 20'$ i.e., $\frac{1}{87}$ th of an acre.

The following are the details of treatments.

Treatment I. The seeds were first soaked in 5% common salt solution for 3 hrs., and sown in plots which were previously irrigated with the saline water from the Ganges. Second irrigation was given with the saline water on the 30th day of sowing i.e., on 27.5.52.

The percentage of germinations in D 154 and 386 were higher than the olitorius types viz. R 26 and C.G. In the former, it was about 75% whereas it was only about 50% in the olitorius ones. After second irrigation the plants started dying out and there were only 10% to 15% plants surviving till maturity. Flowering was much delayed and the fruiting was poor. Many of the fruits did not contain any healthy seeds. The plants also remained stunted. As the same experiment was conducted in the same plot during the last five years, the salinity of the plot increased considerably, as seen from the deposit of common salt in the plot.

The average heights of the types D 154, D 386 R 26 and C.G. were 3'2", 8'0", 4'8", and 5'7" respectively as against 10'9", 11'8", 10'2" and 8'5" in controls and basal diameters of these types were 0.3", 0'5", 0.4" and 0.4" as against 0.7", 0.7", 0.5" and 0.4" in controls.

Treatment II. The seeds were soaked in pond water for 3 hrs and then sown in plots which were previously irrigated with the saline water of the

Ganges. A second irrigation with saline water was given on 27.5.52 i.e., 30th day of sowing.

The percentage of germination in all types in this treatment were almost the same as in treatment I and the survivals were also similar. The plants in all types in this treatment were, however, better than treatment I in that they attained greater heights, bearing greater number of healthy fruits with fertile seeds.

The average heights of the four varieties D 154, D 386, R 26 and C.G. in this treatment were 7'8", 9'8", 7'2", and 7'8" respectively and their basal diameters were 0.5", 0.6", 0.3" and 0.3".

Treatment III. Seeds were soaked with pond water for 3 hrs, and then sown. Irrigation with saline water was given on 27.5.52 i.e., on the 30th day of sowing.

The percentage of germination in all types were from 80% to 90%. But the plants which survived till last were much less. The number started diminishing just after saline irrigation and continued till regular monsoon broke down. Finally there were about 60% to 70% in the two Capsularis types and 40% to 45% in the olitorius ones. In both the vegetative and reproductive phases these plants in this treatment behaved almost like those in controls. The heights (average) of the four varieties viz. D 154, D 386, R 26, C.G. were 9', 10'5", 8'8" and 9'8" respectively and the basal diameters were 0.6", 0.6", 0.4", and 0.4".

Control. The percentage of germination in all types were about 80% to 90% but the olitorius types suffered mortality due to water logging to the extent of 10% to 20%. Out of two olitorius types, C.G. could resist water logging more than R 26, although it was more stunted than R 26.

The average heights of the plants of D154, D 386, R 26 and C.G. were 10'9", 11'8", 10'2", and 8'5" respectively and basal diameters were 0.7", 0.7", 0.5" and 0.4".

As in the previous year, the *capsularis* types were found to be better suited to the saline conditions, than the *olitorius* type.

C.2.3. *Inducing mutations in Til (Sesamum) and Rape and Mustard (Brassica):*

This is a scheme financed by the Indian Central Oilseeds Committee and is in the third year of investigation. The following are some of the important results obtained

C.2.3.1. *Til (Sesamum).*

The season was unfavourable for *sesamum* crop as there was not sufficient rains during the sowing seasons. This affected the germination

and stand to a certain extent. But during the flowering and fruiting stages there was very heavy rains, resulting in the falling down of many of the plants which had more fruits. This adversely affected the fertility and the yield. These heavy rains affected more plants having greater number of flowers and fruits (which were from irradiated stock) than the control plants which had lesser number of flowers and fruits, with the result that the differences during this season are not so marked as in the previous season. But it appears that if the climatic conditions had been as in the previous year, the differences in the yields would have been greater.

The seeds of the four Bengal types, viz. No.10, No. 12, No. 16, and No. 20 and the two Madras types, T.M.V. 1 and T.M.V.2. were again freshly irradiated this year with 100 and 140 m.a.H. in each of the types. These were sown in replications in different fields. The first lots were sown on 14.4.52 out of which all the Bengal types germinated, but not the T.M.V. types. All of them were again sown on 16.5.52 and again on 2.6.52, but the germinations were very poor. In this connection, it will be useful to recall that during the previous season excellent results were obtained with the sowings on 30.5.53, but of those this year during that period were a failure, and hence the results of this year were not as favourable as those of the previous year.

Table 8, gives the dosage and the yield of the four W. Bengal types.

TABLE 8

Type	Treatment	Yield (no. of fruits)
No. 10 Berhampore, W. Bengal	Control	270
	100 m.a.H.	487
	140 m.a.H.	325
No. 12 Berhampore, W. Bengal	Control	180
	100 m.a.H.	220
	140 m.a.H.	217
No. 16 Berhampore, W. Bengal	Control	288
	100 m.a.H.	257
	140 m.a.H.	380
No. 20 Berhampore, W. Bengal	Control	327
	100 m.a.H.	264
	140 m.a.H.	525

Here again as in the previous year, treatments gave a higher yield than the controls. For example in type No. 10, while the best plant in the control had 270 fruits, one plant of the 100 m.a.H treated lot had 487 fruits. In types No. 16 and No. 20 these figures are 180 in the control as against 220, 288 as against 380, and 327 as against 525, respectively.

These results again confirm the previous years findings viz. certain doses of X-radiation induces a larger number of fruits.

It has been claimed by Gustafsson and Mackey (1948) that with low and medium doses of X-rays, the plants exhibit heterosis. This may explain the greater vigour and higher yield observed both in Sesamum and Mustard in the X_1 but not its continuance in the X_2 .

The progenies of the higher yielding T.M.V. types of the previous season were sown again this year without any further treatment and the results are shown in Table 9.

TABLE 9

Type	Treatment	No. of fruits in X_1 (1951)	No. of fruits in X_2 (1952)	No. of fruits of average of ten plants selected at random in (1952)
T.M.V. 1	Control	205	220	160.5
	36 m.a.H.	281	292	224.2
	50 m.a.H.	601	370	296.1
	100 m.a.H.	243	336	255.1
T.M.V. 2	Control	70	82	53.0
	36 m.a.H.	80	150	53.8
	50 m.a.H.	124	100	55.6
	100 m.a.H.	93	236	88.1

In the above table, the figures obtained during the 1951 season are also included for comparison with those of the best plants in the 1952 season and also the average yield (no. of fruits) of ten plants, selected at random. It will be observed that the best plants in T.M.V. I in the X_2 of the 1952 both in 36 m.a.H and 100 m.a.H. gave a higher yield than their respective X_{1s} . This is significant in that it shows that the effects of X-rays in inducing higher yield do not stop with the X_1 generation but may continue also in the X_2 unlike heterosis suggesting the possibility of this method in inducing permanent changes. In the case of the 50 m.a.H, the best among the progenies of the X_1 plant which gave 601 fruits as against 205 in the control gave only 370 as against 220 in the control. But these progenies has a much greater number of flowers and fruits in the initial stages, but unfortunately due to the very heavy rains, all these plants fell down; these could not be lifted up immediately due

to continued rain and the slushy nature of the soil. After they were lifted up, many of the fruits dropped off and hence the lower yield. But they are the best among the lot as seen from the average of ten plants taken at random, which gives a much higher figure, viz., 296.1 fruits as against 160.5 in the control. The average yield of the other two treatments in the X_2 are also much higher than in the controls.

In the case of T.M.V.2 the progenies of the best yielders of the 1951 season both in 36 and 100 m.a.H gave still higher yield in the X_2 viz., 150 fruits in the X_2 as against 80 in the X_1 in 36 m.a.H. and 236 fruits in the X_2 as against 93 in the X_1 in 100 m.a.H. But the 50 m.a.H. which was the highest yielder in 1951 season having 124 fruits gave only 100 fruits in the X_2 in the best plant. The average yield of ten plants in the X_2 does not show much difference in 36 m.a.H. as against the control but is much higher (88.1 fruits) in the 100 m.a.H. This also shows that the result of the X-radiation cannot be anticipated and hence these have to be carried on and studied in the subsequent generations.

The behaviour of the selected plants of X_3 generations in two of the types viz., No. 12 and No. 16, from Berhampore (W. Bengal) were studied in comparison with the X_1 of 1950 and X_2 of 1951 and are contained in Table 10.

TABLE 10

Type	Treatment	No. of fruits in X_1 (1950)	No. of fruits in X_2 (1951)	No. of fruits in X_3 (1952)	Average No. of fruits from 10 plants selected at random in 1952
No. 12 Berhampore, W. Bengal	Control	150	77	150	110.5
	36 m.a.H.	140	178	200	154.9
	50 m.a.H.	144	107	176	121.1
No. 16 Berhampore, W. Bengal	Control	121	116	185	111.1
	36 m.a.H.	125	164	348	200.5
	50 m.a.H.	144	193	302	167.8

It will be seen from the above table that in type No. 12 in the X_1 of 1950, the control was slightly better than the two treatments viz., 36 m.a.H.

and 50 m.a.H.; in the X_2 and X_3 generations, the treatments gave much better yields. The relative figures in the X_2 and X_3 were 77 fruits in the control as against 178 and 150 in the control as against 200 respectively in the 36 m.a.H. treatment. The average yield of ten plants selected at random also gave better yield as seen in the last column, viz., 110.5 in the control as against 154.9, in the same treatment. These figures show that the better results of the X_2 generation are being continued in the X_3 also and it can now be reasonably assumed that they will continue to behave like this in the succeeding generations also.

In type No. 16, the better yields in the X_1 are being continued into X_2 and X_3 generations also and the average yield as shown in the last column also shows an increase over the control viz., 111.1 in the control as against 200.5 in 36 m.a.H. and 167.8 in 50 m.a.H. As in the previous year, the percentage of sterile pollens were continued in the four Berhampore types and the two T.M.V. types.

For these data, approximately 5,000 pollens, from each and treatment from ten plants selected at random were taken into account. It was seen that in all the types, the percentage of pollen sterility is the least in the controls, but greater in the treatments. In three of the types, 100 m.a.H. gave the highest sterility, while in the other three, 140 m.a.H gave the highest sterility.

The variations in the diameter of the pollen grains in the controls and the treatments of the above types were also investigated.

It was observed that in the two of the types the diameter of the pollen grains is least in the control and increase with increase in dosage. In one type, although the pollen grains are larger in the treatments, there is no difference between the treatments themselves. In two other types, one of the treatments had larger pollen grains, the other treatment having slightly smaller grains than the control.

Table 11 gives the age of the plant at the time of the first flowering and at harvesting, together with their relative earliness in the controls and the treatment in the four Berhampore (W. Bengal) types.

It will be seen from the table that the plants in all the types, in both the treatment flowered earlier than the controls, the maximum earliness being 6 days. Many of these were also harvested earlier, in relation to the controls, the maximum being 9 days. If these continue to behave in a similar manner in the subsequent generations, then it will be really good.

TABLE 11

Locality	Types	Control & Treatment	Date of sowing	Date of first flowering	Age of plants at the time of flowering	Earliness or lateness in days	Date of harvesting	Age at the time of harvesting	Earliness in harvesting
Berhampore, W. Bengal	No. 10	Control	14-4-52	28-5-52	44 days				
		100 m.a.H.	"	23-5-52	39 "	5 days early	17-7-52	94 days	
		140 "	"	23-5-52	39 "	5 "	15-7-52	92 "	2 days
"	No. 12	Control	14-4-52	24-5-52	40 days				
		100 m.a.H.	"	19-5-52	35 "	5 days early	10-7-52	87 days	
		140 "	"	18-5-52	34 "	6 "	1-7-52	78 "	9 days
"	No. 16	Control	14-4-52	26-5-52	42 days				
		100 m.a.H.	"	23-5-52	39 "	3 days early	17-7-52	94 "	
		140 "	"	22-5-52	38 "	4 "	11-7-52	88 "	6 days
"	No. 20	Control	14-4-52	30-5-52	46 days				
		100 m.a.H.	"	28-5-52	44 "	2 days early	20-7-52	97 days	
		140 "	"	27-5-52	43 "	3 days early	19-7-52	96 "	1 day
							15-7-52	92 "	5 days

The seeds from the plants which exhibited earliness in the 1951 season were sown again in 1952 without any further treatment and Table 12 gives the results in the four Berhampore (W.Bengal) types and the two T.M.V. (Madras) types.

TABLE 12.

1951		X ₁	1952		X ₂
Type No. & Selection No.		Age of plant at the time of flowering	Earliness	Age of plant at the time of flowering	Earliness
No. 10					
Control		48 days		57 days	
36 m.a.H.	34/19	43 "	5 days	53 "	4 days
50 "	48/25	44 "	4 "	51 "	6 "
100 "	52/48	41 "	7 "	56 "	1 day
No. 12					
Control		47 days		41 days	
36 m.a.H.	20/23	44 "	3 days	42 "	1 day late
50 "	55/19	43 "	4 "	41 "	
100 "	29/27	41 "	6 "	36 "	5 days early
No. 16					
Control		48 days		45 days	
36 m.a.H.	56/13	43 "	5 days	36 "	9 days
50 m.a.H.	60/13	42 "	6 "	42 "	3 "
100 "	27/21	42 "	6 "	not germinated	
No. 20					
Control		50 days	×	42 days	×
36 m.a.H.	7/20	43 "	7 days	46 "	4 days late
50 "	5/40	42 "	8 "	48 "	6 " "
100 "	8/9	41 "	9 "	46 "	4 " "
T. M. V. I.					
Control		50 days		45 days	
36 m.a.H.	4/17	44 "	6 days	42 "	3 days
50 "	6/6	48 "	2 "		
100 "	7/12	48 "	2 "	42 "	2 "
T. M. V. 2.					
Control		50 days		56 days	
36 m.a.H.	13/4	54 "	4 days late	55 "	1 day
50 "	16/8	49 "	1 day early	53 "	3 days

It will be seen from the above table that in many of the types and treatments the earliness is being maintained and in some they showed improved performances. But in a few they were later. For example, the 50 m.a.H. of type No.10, which flowered earlier by 4 days in 1951, flowered earlier by 6 days in 1952. But in both the 36 m.a.H. and 100 m.a.H. treatments, although they flowered earlier in 1952 (X₂) when compared to the control, they were later than in the 1951 season. The maximum earliness of 9 days in the 1952 season was found in the 36

m.a.H. treatment of type No. 16 which in the 1951 season was earlier only by 5 days.

In order to find out the differences in the behaviour of the progenies of the early selections of 1951 (X_1) in relation to the time of sowing ten plants from the early X_{1s} of 1951 of type No. 10, were selected and sown in the X_2 on 22.3.52, 27.4.52 and 15.5.52. The original early strains were selected from the three treatments viz., 36,50 and 100 m.a.H's. As the quantity of seeds in each of them was limited, all could not be sown on all the above sowing dates. The data are included in Table 13.

TABLE 13

Type No. 10	Selection No. of 1951	Earliness in 1951	Flowering behaviour in x_2 1st replication Sowing 22-3-52	Flowering behaviour in x_2 2nd replication Sowing 7-4-52	Flowering behaviour in x_2 3rd replication Sowing 15-5-52
Treatment	21/25	2 days	Not sown	Normal	12 days late
	61/45	2 days	"	12 days late	9 days early
36 m.a.H.	10/47	3 days	"	2 days early	2 days early
	34/19	5 days	4 days early	Not sown	Not sown
50 m.a.H.	15/33		Not sown	2 days early	2 days early
	18/39	4 days	"	2 days late	"
	48/25		6 days early	1 day late	"
100 m.a.H.	2/22	6 days	Not sown	4 days late	8 days early
	43/46	6 days	"	1 day early	9 days early
	52/48	7 days	1 day early	1 day late	Not sown

From the above table it will be observed that all the three strains sown on 22.3.52 were early, the earliness ranging from 1 to 6 days. But in the second sowing of 9 strains of 7.4.52, some were early and some were late. But the third sowing of 8 strains on 15.5.52 eight were early, the earliness ranging from 2 days to 9 days, except in selection No. 21/25, which was sown only on the third sowing date as there were not sufficient number of seeds. It is interesting to note that selection 61/45 which was two days early in 1951, in the X_1 generation, was 12 days late in the X_2 in the sowing on 27.4.52, but 9 days early in the sowing on 15.5.52. There are a number of other similar instances in this table.

These results show that the time of sowing has a great influence on the time of flowering in the above types. The seeds from all this have again been collected and will be sown in during the next season without any further treatment.

The performances of some of these early types in the X_1 , X_2 and X_3 generations of 1950, 1951 and 1952, respectively in two of the Bengal

types, viz., type No. 10 and No. 16 have been observed. The date of sowing, flowering, age of plant at the time of flowering, earliness in days etc. have been recorded in each for the three years. Here also it was noticed that the earliness in some of the selections was being maintained.

C.2.3.2. Rape and Mustard (*Brassica*)

Observations, similar to those on *Til* have also been made in Rape and Mustard, but are not included here for sake of brevity. The full details have been included in the annual report sent to the Indian Central Oilseeds Committee.

(b) Cytological and cytogenetical investigations were undertaken in the controls and X-radiated progenies of *sesamum* and *mustard*, the details of which will be included in the next annual report.

(c) *Oil content and nature of the oil with special reference to sesamum.* Preliminary investigations were conducted to determine the quantity and quality of the oil extracted from the seeds of the control plants and the irradiated progenies. These aspects are very important in oil-bearing seeds, as it is not unlikely that in some of the irradiated progenies, the quantity and quality of the oil may not compare favourably with those in the controls in spite of the fact that they may be early or may have a greater number of fruits and seeds. The following table (Table 14) gives the oil-content in the controls and some of the irradiated progenies.

TABLE 14
EXTRACTION OF OIL FROM SESAMUM SEEDS
Reagent: Petroleum Ether. Boiling Range 60°—80°C.

Locality	Plant	Date of extraction	Field No.	Row No.	Plant No.	Dosage	Per-centage of oil
Tindivanam (Madras)	T.M.V.-1	7-7-1952	1	10	17	Control	51%
"	"	"	4	3	26	36 m.a.H.	48%
"	"	"	1	6	60	50 "	52%
"	"	"	1	7	28	100 "	52%
Tindivanam (Madras)	T.M.V.-2	2-7-1952	1	12	9	Control	48%
"	"	"	1	13	23	36 m.a.H.	50%
"	"	"	1	15	2	50 "	49%
"	"	"	1	17	24	100 "	51%
Berhampore (W. Bengal)	Type No. 16	14-7-1952	2	45	31	Control	39%
"	"	12-7-1952	2	57	8	36 m.a.H.	40%
"	"	14-7-1952	2	41	26	50 "	38%
"	"	12-7-1952	2	59	31	100 "	31%
Berhampore (W. Bengal)	Type No. 20	18-7-1952	2	54	19	Control	37%
"	"	16-7-1952	2	40	10	36 m.a.H.	40%
"	"	18-7-1952	2	19	18	50 "	43%
"	"	16-7-1952	2	36	6	100 "	40%

It will be observed that there is a certain amount of variation in the controls and the irradiated progenies, which has to be investigated in detail for arriving at a correct estimate of the yield.

Again, in considering the quality of the oil, the important factors to be investigated are, the sap value, the iodine value and the peroxide value of the oils. The more the peroxide value, the more the oil is prone to rancidity, which is definitely an undesirable character even if the yield is higher. The results of certain preliminary investigations on these aspects are included in Table 15. The analysis done by Dr. C. V. Ramkrishnan of the Chemistry Department, Bose Institute and Dr. M. Chakravarty of the University College of Science, Calcutta University, is thankfully acknowledged.

TABLE 15
ANALYSIS OF DIFFERENT SAMPLES OF SEASAME OIL

Type	Sap. Value	Iodine Value	Peroxide Value
T. 12. Control	185.6	106.1	5.04
T. 12. 140 m.a.h.	186.6	105.7	5.90
T. 16. Control	187.1	163.6	5.86
T. 16. 36 m.a.h.	185.8	105.0	5.78
T. 16. 50 m.a.h.	186.3	105.2	2.05

It will be seen from the above table that in the case of T. 12, the treatment has a higher peroxide value than the control and hence it is not desirable. But in T. 16, one of the treatments (50 m.a.H.) has a peroxide value only half that in the control, which is definitely better and more over this X-rayed progeny gives higher yield.

C.3. Eradication of weeds by the application of hormone type of selected herbicides

This is a scheme financed by the Indian Council of Agricultural Research and was put into operation in January 1953.

Six weeds were selected for these investigations viz. *Cyperus rotundus*, *Imperata arundinacea* and *Vicia sativa*, which are found in the high lands and *Ludwigia parviflora*, *Chara* sp. and *Rottboellia compressa* which are found in the low lands.

Systematic studies are being made on their (1) seasonal occurrence, habit and density, (2) ecological relationships, means of propagation,

dispersal and growth, (3) methods of identification of the weeds at various stages of development and (4) distribution and density, in relation to the economic plants, such as paddy and jute.

The two herbicides selected for investigation were (1) "Cornox" supplied by Boots Pure Drug Ltd., and (2) "Dicotox" supplied by May & Baker" (India) Ltd. Detailed investigations have been made regarding the concentrations needed to kill the weeds in pots and in the field and their methods of action studied. It has been found that along with the withering of the leaves and their dropping off, the starch in the tissues is depleted and also the xylem vessels get blocked, resulting in the ultimate death of the plant.

C.4. Cytology and Anatomy

C.4.1. Chromosome morphology in some Asiatic Cottons.

Detailed studies of the chromosome morphology of five types of Asiatic Cotton viz: C-11-2; KI; 7070; 7067 and 7036 belonging to *Gossypium arboreum* are being made with special reference to their nucleolar chromosomes, and the number of nucleoli organised at telophase, for tracing their phylogeny and inter-relationships. Such studies are often found to be very helpful in breeding work.

Root tips of these types were collected from mature plants grown in pots and also from seedlings germinated in pots containing moist sand and saw dust and were fixed in different types of fixatives and the usual method of dehydration, infiltration and sectioning were done. Staining was done by Newton iodine-gentian violet and Feulgen-Fast-green technique.

Well spread plates were found in all the above mentioned five types of Asiatic Cottons. In C-11-2, six nucleolar chromosomes were seen; while in KI, 7070 and 7036, only four nucleolar chromosomes were seen. The former is not in agreement with the previous observations, the reasons for which are also being studied.

Idiograms for each of the above types are now being undertaken in order to differentiate the types with respect to the position of primary constrictions, secondary constrictions and satellites and also the length of the chromosomes.

C.4.2. Experimental and anatomical studies on the sensitive and insensitive motor pulvini of the following plants:—*Mimosa spegazzini*, *Averrhoa carambola* and *Sesbania* sp.

C.4.2.1. The structures believed to be effective in *Mimosa pudica* for the execution of movement were observed in these plant pulvini, viz., a spongy aerenchymatous cortex, a stomata free epidermis and differential upper and lower sides. Other features such

as a furrowed epidermis, centralized stele and distribution of stainable contents are similar in sensitive and semi-sensitive plants as against, insensitive plants where such structures are absent. Sac like vacuoles have been observed in *Averrhoa*.

C.4.2.2. Similarity in structure of their autonomous pulvini have been noticed in *Desmodium gyrans* and *Oxalis acetosella*, which belong to widely separated families. There is less similarity of these pulvini with those of allied plants, than with each other. There is no differential cortex, as the movement revolves round the axis of the pulvinus. Special hairs are noticed on the epidermis. Stomata and other kinds of hair are absent.

C.4.2.3. Further studies on the pulvinus of *Mimosa pudica* has been undertaken. The stainable contents are seen to take up the Neutral Red dye and there is a difference in staining reaction between the content in the primary pulvinus and those in the secondary pulvinus. One cell layered sections obtained on the freezing microtome reveal these to be vacuolar in nature.

Attempts are being made to locate mitochondria in active cells. Those of *Azolla* have been determined.

C.4.2.4. Studies on the free nuclei, in *Tal* (*Borassus flabellifer*) are in progress. These are being observed for structure under dark field illumination.

C. 5. Plant Disease

C.5.1. Breeding Virus Resistant Potatoes:

The main work in this laboratory has been directed towards the production of virus resistant varieties with special reference to viruses 'X', 'Y' and 'Leaf Roll'. Major attention is being given to the characters of field-immunity, true-immunity to mosaic viruses and partial resistance to leaf-roll virus.

The character of field immunity has its foundation in the extreme intolerance or hypersensitiveness of the plant tissue to the invading pathogen; the intolerance being shown either in the death of the whole plant following systemic necrosis or in the death of the local tissue at the site of virus entry, producing localised necrotic lesions. Both these results of infection are considered to be different manifestations of the same basic plant response. The ability to respond in this fashion is a character of considerable economic importance in the control of virus diseases. Systemic necrotic symptoms are only rarely to be seen in the field and it seems clear that the localisation of the virus at the point of entry provides mechanism through which the intolerant plants resist, under natural conditions infection.

It has been established that both in the cultivated and in the wild potatoes from South America, the characters of field immunity against the mosaic viruses "X", "Y", "A", and "C" are controlled by single dominant genes N_X , N_Y , N_A and N_C respectively. The old established methods of breeding by intercrossing commercial varieties have been carried out with special reference to the characters of field immunity against the viruses "X", "A" and "C" and to the character of quantitative resistance against leaf-roll virus. The variety *Bismark* is being used as a source for quantitative resistance against leaf-roll virus. The diploid South American wild species, *Solanum simplicifolium* and *Solanum brev mucronatum* are providing field immune characters against the viruses "A", "Y" and "C". The true immunity against virus "X" is available in the U.S.D.A. seedling 41956.

The progenies MD 1819(b), MD 1820(a), MD 1225 and MD 1217(a) were tested during the last year with the viruses for field immune characters.

Heterozygosity is a rule rather than an exception in potato and the range of segregations and recombinations obtained is consequently very wide. Hence selections from the above mentioned progenies were made for further breeding with a view to assemble together all desirable characters. This year, the selected diploid plants with desirable resistant characters have been crossed with *Solanum demissum* (hexaploid), to synthesize tetraploid forms with dominant genes controlling field immunity to viruses "X", "A", "Y" and "C" and adding to it the resistance to blight (*Phytophthora infestans*). *Solanum demissum* forms the basis of resistance to blight. The progenies thus obtained during this year will be tested in the coming year with the viruses concerned and with the local strains of blight.

It was interesting to note both in the field and in the Glass house, the diploid species *Solanum simplicifolium* proved to be resistant to the local strains of blight.

These synthetic hybrid tetraploid progenies will be crossed with the commercial varieties during the coming year, to obtain triple hybrids combining fertility with necessary resistance to blight and field immunity to the viruses concerned. In selecting commercial varieties for this purpose particular attention is being given to the resistance to leaf-roll virus.

Attempts are being made to continue work in this direction with the progeny MD 1821(a) which appears to have resistance to leaf-roll, field immunity to virus "Y" and true immunity to virus "X". The progress seems to be promising. During the coming year, final selections will be made from this progeny for these characters which will be followed by trial in the field. The form of resistance to leaf-roll concerned in this

progeny is that of a partial resistance type obtained from the variety *Bismark* in which virus concentration is continually kept at a very low level; so that if a plant becomes infected it practically shows no symptom. Moreover, only an occasional tuber progeny becomes infected. This means that a crop of potatoes with this form of resistance will considerably check the spread of the virus within it.

Although viruses "A" and "C" are not common in the local crop, yet breeding has been directed towards the production of varieties field-immune from them mainly with a view to safeguard the proposed new varieties against any anticipated attack from these viruses.

Attempts are also being made to study the inheritance and the relationship of the genes controlling field immunity in the diploid species to the viruses "X", "Y" and "A" and "C". These are also being supplemented by the study of inheritance of colour and of other morphological characters.

The first year progeny raised from the crosses *Solanum polyadenium* which is resistant to aphid transmitting virus "Y" and U.S.D.A. seedling 41956 which is immune to virus "X" has been tested this year and selections have been made for further breeding.

A number of European varieties of potatoes are being tested in this laboratory with a view to utilise them for resistance to different viruses. They are being replicated in the fields attached to this laboratory.

C.5.2. Raising virus free nuclear stock:

Attempts are being made to raise virus-free nuclear stock from local varieties and their selections. Firstly selections are being attempted in the fields to obtain virus-free stock. These selected plants are being tested by sap-inoculation on different host plants and by graft inoculation on different disease free European potato varieties and also by serological methods. Unfortunately not much of success has been achieved in this direction.

Attempts are being made in another direction by collecting *true-seeds* from the different varieties and by raising new set of plants from them in the insect proof glass house. This year, seeds have been collected from the local varieties and their selections. In this connection the well known fact that potato viruses are not transmitted through *true-seeds* may be remembered.

C.5.3. Physiological studies:

Influence of different physiological conditions on the expression of hypersensitive reactions (field immunity) in potato plants are being

studied. These include studies on the effect of light intensity and of the age of the host plant on the necrotic reaction to leaves inoculated with virus "Y". Further studies are being carried out to elucidate the mechanism of hypersensitive reaction in leaves.

C.6. Palaeobotany

C.6.1. Cambrian microflora and plant phylogeny:

The occurrence of remnants of advanced plants with well-developed vascular system has already been noted in our previous reports in the undisputable Cambrian and pre-Cambrian rocks of the Punjab Salt Range, the Vindhya and Kashmir. This phenomenon, which has repeatedly and definitely been proved to be widespread, indicates clearly that the vascular plants have their origin and development in that remote Cambrian period. This assumption has gained further evidences in its favour as a result of the examination of 9 North-American Cambrian rock-specimens during the year under review. The samples have been received from Prof. B. F. Howell of the Princeton University, U.S.A., who himself is the collector of 5 samples out of nine. The following table gives a short description of the rocks examined:—

Serial No.	Sample	Horizon	Locality
1.	219 B 5c	Brigns Formation, Callavia Zone, Lower Cambrian.	Manuels, Conception Bay, Newfoundland.
2.	307 B6	Bonavista Formation, Lower Cambrian.	Grand Bank Cape, North of Fortune, Fortune Bay, Newfoundland.
3.	210 A6c	Manganiferous shale of late Early Cambrian age, Protolenus Zone, Hanfordian Series.	As in 1.
4.	210 B1a	Metadoxides Beds, Hanfordian Series, late Early Cambrian.	Do.
5.		Eager Formation, late Early Cambrian.	Cranbrook, Br. Columbia.
6.		Stephen Formation, Middle Cambrian.	Mount Stephen, Br. Columbia.
7.		Braintree Formation Paradoxides harlani Zone, Middle Cambrian.	Braintree, Massachusetts.
8.		Limeport Formation, early Late Cambrian.	Limeport, Pennsylvania.
9.		Kittatinny Formation, late Late Cambrian.	Newton, New Jersey.

With every possible precautionary measure against laboratory contaminations, rocks have been macerated in a solution of equal parts of Nitric acid and Hydrochloric acid. All washings in distilled water both before and after 5% KOH solution-treatment have been done by means of a buchner funnel through a thick bed of filter paper under low pressure.

In samples 1 and 2, besides abundant algal remains and other thallophytic plant remnants, carbonized wood elements mostly structureless and rarely with pit-remnants, spores and cellular structures of unknown affinities are found.

But samples 3-7 have yielded microfragments of carbonized woods with various types of thickening viz., scalariform, bordered, apparently simple, pinhole like pitting, spiral etc, several types of spores, cuticular and cellular structures most of which are somewhat comparable to those already recorded from the Cambrians of Kashmir, the Vindhya and the Punjab Salt Range.

C.6.2. Tertiary:

Fifteen samples of peats collected from Madhyamgram, Jadavpore and Tollygunj areas near Calcutta have been examined and the microflora obtained include mainly pollens of Gramineae. Pteridophytic spores are also found. It is interesting to note that the lowermost beds of this Calcutta peat have yielded sponge spicules abundantly.

Three fossilized woods from Mayurbhanj area obtained through the courtesy of the Anthropology Department of the Calcutta University have been sectioned and worked out. One of them has been identified as belonging to Dipterocarpaceae.

D. MICROBIOLOGY

The following investigations were undertaken during the period under review:

1. Studies on the rate of inhibition of *Azotobacter* and Root nodule bacteria by Terramycin.
2. Studies on the effect of pure antibiotics on the nitrification process in soil by perfusion method.
3. Further studies on the isolation of micro-organisms from the soil of West Bengal with special reference to their antibiotic properties.
4. The effect of dye-stuff on the isolation of microorganisms from soil.
5. Identification of *Streptomyces* spp. isolated from soil collected from different parts of the country.

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6. Studies on the isolation, purification and properties of an anti-fungal substance from a spore-bearing bacillus.
7. Studies on the production of an antibiotic by a *Streptomyces* sp. active against gram-positive, gram-negative and acid-fast organisms.
8. Studies on the antibiotic activity of a strain of *Penicillium* identified as *P. vermiculatum*.

D.1. Effect of Terramycin on the rate of inhibition of nitrogen fixing bacteria:

In continuation of the work reported earlier, the effect of Terramycin on the rate of growth of *Azotobacter* sp. and *Rhizobium* spp. has been studied. Six hours were found to be sufficient for 25 mg/ml of Terramycin to completely inhibit the Az(x) strain of *Az. indicum*, while 100 mg/ml took only 3 hours. The same concentration could inhibit Az (128) strain of *Az. chroococcum* for the first 24 hours only after which the number of organisms became greater. However, none of the concentrations used was bactericidal for the Pea strain of *Rh. leguminosarum*, though the initial growth rate was affected by all the concentrations. Concentrations of 10 mg/ml. and above proved to be completely bactericidal for Soybean strain of *Rh. japonicum*, the time taken being 48-72 hours.

D.2. The effect of antibiotic substances on nitrification in soil:

With a view to studying the inhibition of nitrification by antibiotic substances in a cultivated field, a specially constructed soil perfusion apparatus was set up after the pattern of Lees and Quastel with some modifications as suggested by Audus. The soil used in this investigation was collected from the Experimental Farm of the Institute at Bamangachi, 20 miles north of Calcutta. 50 gms. of sieved soil were perfused with 250 ml of N/50 $(\text{NH}_4)_2\text{SO}_4$ solution in the presence of different concentrations of Dihydro-streptomycin sulphate and Penicillin. Samples of the perfusate were taken after 3, 7 and 10 days and they were analysed for ammonia-, nitrite-, nitrate-N by standard methods. Controls were also run simultaneously in a separate apparatus.

(a) *Effect of Streptomycin:* From the results obtained it appeared that Streptomycin at a concentration of 100 mg/ml inhibited nitrification in soil in less than 3 days' time. The small amount of nitrate-N detected in the perfusate probably represented the nitrates that were already present in the solution together with the little nitrate that was formed during the early stages. Streptomycin appeared to be toxic to both the nitrite-forming as well as the nitrate-producing organisms. The small amount of nitrite that was present could not be oxidised probably due to the complete inhibition of the nitrite oxidisers before this nitrate was produced.

(b) *Effect of Penicillin*: Penicillin used at a concentration of 100 IU/ml was found to affect the process of nitrification during the early stages but later the power of nitrification was recovered. For the first 7 days the concentration of nitrites increased possibly due to the reduction in the activity of the nitrate formers. In 10 days the effect appeared to have been overcome and nitrification proceeded vigorously.

D.3. Further studies on the occurrence of antibiotic producing fungi and actinomycetes from soils of West Bengal and Assam:

Altogether 45 soil samples were analysed in the year under review. Of the 490 isolates belonging to *Streptomyces* spp. and fungi, 135 strains were screened for antibiotic activity both by agar streak and cup-plate methods against *S. aureus*, *B. subtilis*, *B. cereus* var. *mycoides*, *Eb. typhosa* and *V. cholerae*. For cup-plate assay the fungi were grown on modified Czapek-Dox media at 25°C and assay was made at the end of the 4th day. In the case of *Streptomyces* spp. modified straw infusion dextrose broth was used, the assay being made at the end of 8th day. The pH was adjusted to 7.2 when necessary. Results will be seen from Table I.

TABLE I
ANTIBIOTIC SPECTRUM OF SOIL FUNGI AND ACTINOMYCETES

Number soil samples analysed	Total number of strains isolated	Number of organisms tested	Number of strains showing positive activity	Number of strains showing positive activity against		
				Gram-positive bacteria	Gram-negative bacteria	Both gram-positive & neg-bacteria
45	Actinomycetes— 324	84	34	14	—	20
	Fungi— 166	51	14	7	8	3

Of the 20 strains belonging to *Streptomyces* spp. tested for their antifungal action against plant pathogenic fungi which included *Helminthosporium oryzae*, *Helminthosporium* sp., *Curvularia* sp., *Verticillium* sp., *Alternaria solani*, *Cephalosporium saccharum*, *Fusarium* sp., 12 were found to be completely negative while the rest possessed activity against some of the strains. *Fusarium* sp. was found to be the most resistant. Two strains possessed considerable action against all the fungi mentioned excepting *Fusarium* sp. It is now intended to study the application of antifungal agents as systemic fungistatic substances.

Attempt is now being made to isolate aerobic nitrifying organisms by the enrichment culture method in Winogradsky and Fred and Davenport's media. Purification up to certain stage has been attained.

Attempt is also being made to isolate different strains of *Chromobacter* spp. from the soil by the inoculation of sterile rice grains on moist soil spread over a sterile petri dish.

D.4. Use of Dyes in the isolation of soil microorganisms:

The use of dye-stuffs in the isolation of soil microorganisms are known for a long since. Crystal Violet and Congo-Red are used in the selective isolation of *Rhizobium* and *Azotobacter* in routine works in this laboratory. The utilization of Rose Bengal for the isolation of *Rhizobia* has recently been investigated by Gamble and Cut (1951). Sodium propionate, though not a dye, in different concentrations, has been recommended for the selective isolation of Actinomycetes from soils (Crooks, Carpenter and Klens, 1950). Mukherji & Nandi (1952) however found it to act as a general inhibitory agent on all the groups of soil microorganisms. Sulpha drugs and antibiotics are also used recently in the isolation of certain microorganisms (Florey, Chain, *et al*, 1949). Studies have been made with certain dye-stuffs known to possess antimicrobial properties.

Norris medium highly suitable for the isolation of soil microorganisms was used as the basal medium. Rose Bengal, Congo Red, Brilliant Green, and Crystal Violet were used in concentrations of 1:10,000 and 1:50,000. 1 ml of a 0.1% and 0.5% stock solution of the dye previously sterilised added to each 100 ml of the medium brought to the desired concentration. A millionth dilution of a sample of Indian Botanic Garden soil was plated out in Norris medium containing the dye, the inhibitory effect of which was studied. The results are given in Table II.

TABLE II.

Medium used	Total no. of Colonies of Micro- organisms	Total no. of Colonies of Fungi	Total no. of Colonies of Actinomycetes	Total no. of Colonies of Bacteria
*Norris + R. Bengal (1 : 50,000)	26.5	14.5	0.0	12.0
Norris + R. Bengal (1 : 10,000)	8.0	5.5	0.0	2.5
Norris + B. Green (1 : 50,000)	7.0	0.5	0.0	6.5
Norris + B. Green (1 : 10,000)	1.5	0.0	0.0	1.5
Norris + C. Red (1 : 50,000)	120.5	3.0	2.5	115.0
Norris + C. Red (1 : 10,000)	97.5	2.5	3.5	91.5
Norris + C. Violet (1 : 50,000)	13.0	0.0	0.0	13.0
Norris + C. Violet (1 : 10,000)	1.5	0.0	0.0	1.5
Control	60.0	9.5	3.0	47.5

*Norris—Norris medium.

It appears that such low concentrations as 1:50,000 of Rose Bengal, Brilliant Green, Congo Red, are inhibitory to soil micro-organisms, particularly to actinomycetes. Congo Red promoted the growth of bacteria but inhibited the fungi, leaving the Actinomycetes unaffected. Rose Bengal stimulated the growth of fungi in concentration of 1:50,000 but bacteria and actinomycetes are adversely affected. Brilliant Green acts as a general inhibitor to all the groups of soil micro-organisms. Crystal Violet completely inhibits the growth of fungi and actinomycetes; the bacteria are affected at higher concentrations.

None of the dyes can be recommended for the selective isolation of a particular group of organisms. Rose Bengal, however, can be used in concentrations of 1:50,000 or near about the isolation of fungi as the actinomycetes are completely inhibited and the bacterial count is considerably reduced. Except Brilliant Green, low concentrations of the dyes used failed to inhibit the bacteria to a marked degree. Brilliant Green in low concentration inhibit the fungi also and so cannot be used in mixture with Rose Bengal for selective isolation of fungi. The use of antibiotics remarkable for their antibacterial properties, may be utilised successfully. This is borne out by the findings of Martin (1950) who claimed to have obtained very good results with Rose Bengal (1:50,000—30,000) supplemented with 30/ μ g/ml of streptomycin.

D.5. Identification of Soil actinomycetes :

A systematic study of the *Actinomycetes* spp. isolated from different parts of the country was undertaken. The classical methods described in Bergey as also by Gottlieb and Pridham based on the utilisation of carbohydrates were tried. Fifty strains which possessed antibiotic action, were selected for identification. The most frequently occurring strains belonged to *S. fradiae*, *S. alboflaves*, *S. Californicus* or *S. albosporeus* group, while three have been identified as *S. Californicus* and two as *S. albosporeus*, the rest differed somewhat in carbohydrate utilisation from the standard strains. Strains belonging to *S. griseus* group were conspicuously absent. Of the rest, five belonged to *S. antibioticus* group two were identified as *S. reticuli* and one as *S. lavendulae*, while two other differed somewhat from either strain. The remaining three belonged to *S. flaviviriens* group; while there were some which remained as unidentified.

D.6. An antifungal substance from a strain of *B. subtilis*:

Though a considerable amount of literature has accumulated regarding the antibacterial action of *B. subtilis*, less attention has hitherto been paid towards the antifungal action of the bacillus

In course of our investigation on the occurrence and isolation of antibiotic-producing micro-organisms from soil and infected foodstuff,

an effort was made to collect different strains of the bacillus which would produce antifungal action specially against plant pathogenic fungi. The report of one such strain B (X) isolated from decomposed foodstuff and identified according to Bergey is recorded here.

The bacillus was grown both in potato-peptone broth and yeast extract-sucrose broth at 30°C for 5 days in shallow layers of 30 ml. Erlenmeyer flasks. The culture filtrate was heated for 15 minutes at 60°-70°C and the active principle was isolated by acidification with dil. HCl; isolation was done more effectively by extracting the culture filtrate with n-butanol and evaporating at 60°-70°C *in vacuo*. The residue was repeatedly washed with water, the wash-liquor discarded and further purification was effected by dissolving the former in alcohol and reprecipitating with ether when an orange-white precipitate was obtained. The solution was kept overnight at 4°C, centrifuged and the residue dried to give a dark yellowish mass.

The substance was found to be insoluble in dil. HCl but soluble in ethonal, butanol, dil. NaOH and 3% NaHCO₃ solution. It gave negative tests with Fehling's Soln., 2-4-dinitrophenyl hydrazine and Ehrlich's reagent. No colouration was obtained with FeCl₃. The substance gave positive biuret and ninhydrin tests. Test with Millon's reagent indicated a faint pink colouration.

When kept at 4°C the antibiotic retained its activity for more than three months. It was found to be stable when autoclaved at 120°C for 10 minutes but less so in alkaline solution.

The antifungal action of the substance as determined by the agar cup and agar streak methods is shown in Table II.

TABLE II

Test organisms	Minimum inhibitory conc./ml.
1. <i>A. niger</i>	12.0 g
2. <i>P. notatum</i>	12-15.0 g
3. <i>A. oryzae</i>	20-25.0 g
4. <i>Alternaria solani</i>	25.0 g
5. <i>Pythium</i> sp.	02.0 g
6. <i>Fusarium</i> sp.	30.0 g
7. <i>B. cinerea</i>	15.0 g

It was also active against *Curvularia* sp., *Verticillium* sp., *Phoma* sp., *P. rotundum* and *Trichophyton* sp. but inactive against *Epidermophyton* sp. and *Microsporum* sp. at a concentration of 0.2 mg/ml.

The substance was thus found to possess a broad antifungal spectrum but little action was shown against the bacteria tested viz., *Staph. aureus*, *E. coli*, *V. cholerae*, *K. pneumoniae*, *Eb. typhosa* and *Strept. haemolyticus*.

The antibiotic appeared to be homogeneous as single spots moving near the solvent front were revealed on the paper chromatogram when tested with ninhydrin as also microbiologically by using n-butanol-acetic acid-water or ethyl alcohol-water mixture (R_F about 0.67) as the developing solvent. The potentiometric titration of the substance with NaOH gave a pK of about 5.8.

Since the antibiotic was supposed to be a polypeptide in nature, its acid-hydrolysate was subjected to both one and two dimensional paper chromatography using phenol, water and benzyl alcohol-acetic acid-water (25:5:6.5) mixtures as solvents. The following amino-acids were revealed on the chromatogram viz., (1) aspartic acid, (3) glutamic acid, (4) serine, (5) threonine, (6) alanine, (7) tyrosine, (8) nor-valine, (9) phenylalanine, (2 & 10) unidentified spots. The maximum intensity of the spot due to serine indicated predominance over others. Glutamic acid was however found to be present in minute quantity.

The antibiotic was found to be strongly haemolytic and 50-100 mg. of the substance per Kg. body weight injected subcutaneously to mice was tolerated with difficulty. Further toxicity tests were not attempted in consideration of its strong haemolytic action. The incorporation of 10% horse serum in the assay medium partly diminished the activity of the substance against *A. niger* which was probably due to a certain neutralizing action of the former.

The substance differs from bacillomycin, mycosubtilin and fungistatin, known antifungal products of *B. subtilis*, in its anti-fungal and anti-bacterial properties. When compared with bacillomycin, though half neutralisation values lie closer, the substance is characterised by its very low glutamic acid content, relative preponderance of serine and distinct presence of larger number of amino-acids in the acid-hydrolysate. The substance seems to resemble more closely with the incompletely characterised 'aspergillus factor' as regards its anti-microbial properties.

D.7. Studies on the Production of antibiotic Substance by a *Streptomyces* sp.

A strain of *Streptomyces* sp. isolated from the soils of West Bengal was found to possess antibiotic action against gram-positive, gram-negative and acid-fast bacteria. A detailed morphological and physiological study of the strain was undertaken in order to identify it. Differential tests also conducted on the basis of carbohydrate utilisation for growth

revealed that the strain failed to utilise d-sorbitol and mannitol while in the case of sucrose doubtful result was obtained. The strain was found to belong to *S. fradiae*, *S. Californicus*, 8-80 group (acc. to Gottlieb and Pridham's classification). It was active against *E. coli*, *E. coli* R. (resistant to streptomycin), *B. cereus* var *mycoides*, *B. subtilis*, *V. cholerae*, *A. aerogenes*, *Eb. typhosa*, *P. vulgaris*, *S. aureus*, *C. diphtheriae*, *S. paradysenteriae* and *M. phlei* and inactive against Enterococci, *P. pyoceaneus*, *A. niger* and *Pythium* sp. There was little change of the antibiotic action as determined by the cross streak method even on prolonged incubation at 37°C. Of the media tried, modified straw-ext-dextrose broth was found to give the highest titre on 10th-12th day in stationary cultures at 30°C when the pH of the medium changed from 7.4 to 6.3. Study on the effect of glucose and CaCO₃ on the antibiotic titre showed that 2% glucose with the addition of 0.75% CaCO₃ gave the highest results. The ratio of dilution assay against various bacteria to dilution assays against *E. coli* as determined by the cup-plate method showed the following results:- *E. coli*—1.0, *B. subtilis*—0.45, *S. aureus*—0.40, *A. aerogenes*—1.50, *B. mycoides*—0.50.

Morphologically the strain was found to differ from the neomycin-producing strain of *S. fradiae* (ATCC 10745). The method of purification consisted of absorption of culture filtrate by 'Norit' SBX 30, elution by means of 80% acetone acidified (pH 2.2) with H₂SO₄, removal of acetone by evaporation under *vacuo* and precipitation by the addition of 5 vol. of acetone. The precipitate thus obtained was dissolved in minimum amount of water and the antibiotic was reprecipitated down by acetone. The active principle was found to be stable at 100°C for 30 minutes in presence of cysteine and at an acidic pH. It was readily soluble in water but insoluble in organic solvents. A comparative study by means of paper chromatography using n-butanol-piperidine-p-toluene sulphonic acid and methanol-water (9:1) indicated that the substance was different in nature from streptomycin, streptothricin, and neomycin sulphate (Res. No. 9291. The Upjohn company).

Toxicity tests carried out so far against 20 gm. white Swiss mice revealed that intramuscular dosages of 125 dilution units were tolerated. Details of chemical tests will be reported when results of the micro-analysis of a derivative of the compound (a helianthate) will be made available to us.

A systematic study on the toxicity of the compound is now being carried out.

The effect of trace elements on the production of the antibiotic principle is also being investigated.

D.8. Studies on the antibiotic activity of P. vermiculatum:

In course of our routine attempts to screen the strains of fungi isolated from the soil collected from different parts of the country which have not yet been reported as showing antibiotic activity, we came across a strain of *Penicillium* which was found to have conidial heads bi-verticillately symmetrical. Colonies showing various shades of colour formed abundant perithecia 150-187. The mature ascospore (4.5-5.4 $\times$ 3.9) showed characteristic elliptical form and echinulate walls. Initials of perithecia were recognised on corn meal agar. The antheridia connected at the base was found to coil round the clavate to vermiform ascogonia up to certain length. The asci, (7.2-9) oval when mature, was found to be 8-spored. The strain was thus found to belong to *P. vermiculatum* Dangeard sp. The strain exhibited antibiotic action against *S. aureus*, *S. viridans*, *S. haemolyticus* and *E. coli*, being more active against the gram-positive organisms. The strain was found to possess antifungal action also. But it possessed considerable action against the nitrogen-fixing bacteria viz. *Az. indicum*, *Az. chroococcum* and different strains of *Rhizobium* spp. which included pea, Lathyrus, lentil, gram, Phaseolus, Cajanus and soybean. The highest antibiotic titre was obtained when a mixture of glucose and sucrose (1:1) was used as carbohydrate source. Certain degree of purification has been attained by adsorbing the culture filtrate on Brockmann's Alumina IV at pH 4.5-5.2 and eluting by means of phosphate buffer at pH 7.6-7.8 but nothing crystalline has been obtained as yet.

D.9. The possibility of introduction of red clover and alfa alfa in the warm temperate regions of the district of Darjeeling:

(1) Red Clover : A preliminary experiment in the field and another in pots showed that red clover may be easily adapted to the local conditions of growth in the district. The nodules produced on the plants were of the effective type. In another experiment, red clover plants grown in test tubes without added nitrogen in the media and supplied with *Rhizobium* isolated from nodules of local white clover, showed ineffective response towards nitrogen fixation. The presence of both effective and ineffective strains of *Rhizobium* for clover in the Darjeeling soil is evident.

(2) White Clover : The local white clover grown in test tubes showed good response with Rothamsted strain A121111.

(3) Alfa alfa : Plants from seeds obtained from Rothamsted showed definite signs of malnutrition in experimental plots both at Jalapahar and Birch Hill areas. Their nodules were small, whitish brown, rough and hard.

Investigation into physiological condition of growth in soil and seed inoculation with a good effective strain of bacteria may be useful in case

of alfa alfa. Preliminary investigations on clover call forth further detailed work especially on competition of an effective strain with the microbial flora of the soil.

Receipt of seeds of alfa alfa and the strains of *Rhizobium* from Dr. H. G. Thornton, F.R.S., Head of the Department of Soil Micro biology, Rothamsted Experimental Station, Harpenden, England, is thankfully acknowledged.

E. ZOOLOGY

E.1. *Effect of antibiotics on the metamorphosis of tadpoles of Rana tigrina:*

Tadpole-experiments were continued throughout the year. Three out of four surviving tadpoles of the previous year died without metamorphosis on different dates by the month of May, 1952. The remaining one retained its activity till the middle of June, 1952, while in one evening it failed to struggle any more and came to the surface of water floating on its back. Perhaps it was due to contamination of the tank water. However, this tadpole retained its larval form for more than a year.

In the middle of May, 1952 about 200 tadpoles of *Rana tigrina* in the early stage of maturity, were selected for experiments and 150 of them were equally distributed in six vessels containing penicillin water in different strength. All tadpoles in vessels containing over thousand units of penicillin died within two days. But most of the tadpoles (except few deaths) kept in the vessels containing less than hundred units of penicillin remained active. After penicillin treatment for different lengths of time, all the tadpoles were removed to fresh water in bigger tanks and regularly supplied with food. All the tadpoles which were set aside as control, transformed into froglets within a month's time, whereas not a single one from the treated groups metamorphosed even after three months or more. For inducing metamorphosis (as in the case of Mexican *Axotol*) powdered thyroid gland and liver were added to their usual food but with no effect. A few days after these feeding experiments death-rate increased gradually and some peculiar deformities, such as asymmetric condition of the body, abnormal bulging of the posterior portion of the body and stiff, wavy form of tail etc. appeared in some of the specimens. So the remaining tadpoles were transferred to a bigger jar containing aquatic weeds. Here they seemed to be quite active and lively. For about nine months till January, 1953, they retained their larval forms. Further observation was not possible but investigation will be started afresh when specimens are again available.

E.2. *Effect of starvation on metamorphosis:*

The surplus tadpoles of the catch of 1952, were set apart unattended in a dark corner of the room. More than two months elapsed when one day at the time of removing the old articles, attention was drawn to

of alfa alfa. Preliminary investigations on clover call forth further detailed work especially on competition of an effective strain with the microbial flora of the soil.

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the jar. A number of tadpoles were found to be resting at the bottom of the jar. They seemed to be slightly smaller than before. Their colour had been changed and looked like albinos, but not like those that are found in natural condition. The jar with the tadpoles was then placed on a table in an open place for further observation. Their activities seemed to be accelerated in the new surroundings and they were running here and there in search of food. As no food was supplied to them they fell upon the weaker ones and devoured them by tearing their bodies to pieces. So some of them were separated and supplied with food; but the supply was not regular and sufficient. The rest of the tadpoles remained without food. Metamorphosis did not take place in any one of those jars. The starved tadpoles gradually decreased in number and within a few days completely disappeared. The half-starved tadpoles survived for a longer time without metamorphosis.

F. WORKSHOP

Repair and constructional work on specifications received from Physics, Chemistry, Botany and Microbiology departments were carried out. The following is a list of the major jobs which have been finished or nearly completed during the year.

1. *Continuous Working Cloud Chamber.*
2. *A large Ionisation Chamber of volume 40 litres.* The Chamber after being assembled has been tested up to a hydraulic pressure of 1200 lbs. per sq. inch.
3. *Rectangular shaped Cloud Chamber* of dimension $20'' \times 20'' \times 12''$.
4. A pair of Coils for an electromagnet, which can carry a current of about 200A. have been wound. Each coil has three separate windings wound on brass bobbins with $1\frac{1}{2}'' \times 1/32''$ copper tapes under high tension, being properly insulated by empire cloth between each layer. For applying tension on copper tape and easy winding one specially designed gadget was constructed. The coils will be used in an electromagnet consuming 25 kw power to produce a magnetic field of the order of 10,000G.
5. *One electric motor driven shaker* having capacity to hold 12 conical flasks.
6. *Electrophoresis Apparatus.* The optical bench and all the angle iron plates for holding light source, thermostat and camera were completed. The remaining works are in progress.
7. *High Intensity Microscope Lamps.* Six lamps are under construction, out of which 2 have been completed. All parts excepting the lenses were designed and constructed here. The special features of the lamps being the low power consumption. The cost of construction works out to about 50% of market price.

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In the carpentry shop besides various works in connection with research and usual maintenance work, some furniture were made for the Institute.

Weekly cleaning and checking of all electrical motors, generators, converters, refrigerators and air conditioning units were carried out as usual. Besides these some electrical motors, fans and measuring instruments were also thoroughly repaired in the workshop. Repairing and overhauling of pumping sets at Falta and Bamangachi Experimental Research Stations were also carried out.

G. LIBRARY

The Library consists of 3,228 volumes (1,617 books and 1,611 periodicals). During the year under report 140 volumes (65 books and 75 bound periodicals) were added to the stock as against 147 during the previous year. The total number of periodicals received was 93 (inland 15 and foreign 78), out of which 47 were purchased and the remaining 46 were received in exchange of Institute publications. The Library also received a large number of technical pamphlets, bulletins, circulars, etc. from various Research Institutes and Government Departments, both inland and foreign.

The total number of volumes issued out of the Library was about 2,500 and the volumes consulted in the Reading Room was more than 6,000.

The Bose Institute Library is primarily meant for use of its research staff only. But it is very frequently consulted by research workers and scientists from other institutions on account of its well-arranged selected acquisitions and efficient service. The number of such visitors are gradually increasing from year to year.

With the increase of research staff in the Institute, there has been a growing demand for books and journals in the Library. Due to restriction of funds, however, it has not always been possible to meet their demands. It is felt that further additions of important books and journals are extremely desirable to meet the requirements of the staff as well as to build up an up-to-date Research Library.

H. PUBLICATIONS

During the year under report Vol. 18 (1949-51) of the TRANSACTIONS OF THE BOSE RESEARCH INSTITUTE was published and about half of the stock was exhausted by way of sale, gifts and exchange of periodicals. Exchanges of *Transactions* mostly with foreign periodicals were considerably increased. Many important and popular works of Sir J. C. Bose viz.,

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"Response in the Living and Non-Living", "Plant Response", "Researches on Irritability of Plants", "Plant Autographs and their Revelations", etc. have been out of print for a long time. Efforts are being made to reprint some of them in the near future and the book entitled "Plant Autographs and their Revelations" is now in the press. Other publications published during the year under report include (1) Annual Report for 1951-52 and (2) The Fourteenth Acharya Jagadish Chandra Bose Memorial Lecture on "Growth of Scientific Spirit in Ancient India" by Dr. R. C. Majumdar with Director's report.

APPENDIX

I. The Governing Body:

Dr. Debendramohon Bose
(A.S.I.) Mr. Sudhansu Mohon Bose
Mr. Kedarnath Chatterjee
Mr. Sudhir Kumar Mandal
Mr. Abani Nath Mitter
Dr. Sisir Kumar Mitra
Mr. Satish Chandra Mukherjee I.C.S. (Retired)
Mr. Khitish Chandra Neogy
Mr. Bhupati Mohon Sen I.E.S (Retired).

II. The Council:

Mr. S. M. Bose
Mr. K. N. Chatterjee
Mr. S. K. Mandal
Mr. A. N. Mitter
Dr. S. K. Mitra D.Sc., F.N.I.
Mr. S. C. Mukherjee I.C.S. (Retired)
Mr. B. M. Sen I.E.S. (Retired)
Dr. D. M. Bose M.A., PH.D., F.N.I., (*Ex-officio*)
Dr. S. S. Bhatnagar, D.Sc., F.R.S., F.N.I., Secretary, Ministry
of Natural Resources and Scientific Research, Govern-
ment of India (nominee of the Central Government)
Dr. S. R. Chatterjee, M.P. (representative of the Parliament)
Dr. K. Krishnamurti, D.Sc. (London), Principal, Science
College, Nagpur.
Dr. P. Parija, D.Sc., F.N.I., I.E.S. (Retired) Pro-Chancellor,
Utkal University, Cuttack.
Mr. Nandadulal Sreemany (representative of the Corporation
of Calcutta).

III. Finance Committee:

Mr. B. M. Sen *Chairman*
Accountant General, West Bengal
Dr. D. M. Bose (*Ex-officio*)

IV. Building Committee:

Dr. D. M. Bose
Mr. K. N. Chatterjee (representative of the Council)
Mr. A. N. Mitter (representative of the Governing Body)

V. Staff:

Director—Dr. D. M. Bose, M.A., PH.D., F.N.I.
Registrar—Mr. A. K. Ghosh
Special Officer—Dr. J. P. Sircar
Superintendent (Workshop)—Sri M. L. Chatterjee (from 1.5.52)

Department of Physics:

Head of the Department—Director
Research Scholar—Mr. T. C. Bhadra M.sc.
Attached Worker—Prof. H. P. De, M.Sc., P.R.S. (Vidyasagar College)

Department of Chemistry:

Head of the Department—Dr. J. K. Chowdhury, M.A. PH.D., F.N.I.
Research Fellow—Dr. B. Banerjee, (Dr. Phil. Nat) on leave
 „ Dr. A. Sen, M.sc., PH.D. (Leeds) from 1.7.52
Research Assistant—Dr. D. P. Burma, M.sc., D.Phil.
Birla Scholar—Dr. C. V. Ramakrishnan, M.sc., PH.D., (from 1.1.53)
Govt. of India Senior Scholar—Mr. R. K. Bose, M.sc.
 „ *Junior Scholar*—Mr. C. R. Raha, M.sc.
 „ „ Ajoy Kumar Guha M.sc.
Attached Worker—Mr. N. N. Banerjee (Textile Inst. Serampur)

Department of Botany:

Head of the Department—Dr. K. T. Jacob, M.A., PH.D.,
Research Fellow—Dr. S. K. Roy, M.A., PH.D.,
Research Assistant—Mr. B. K. Palit, B.sc.
 „ Mr. B. K. Datta, B.sc.
 „ Mr. A. T. Guha Thakurta
Research Scholar—Mr. S. B. Sarkar, M.sc.
Govt. of India Junior Scholar—Mr. Samir Kar, M.sc. Ag. (from 1.4.52
 „ Mr. Apurba Kumar Ghose, M.sc. upto 31.10.52.
 „ Mr. Smritimoy Bose, M.sc. (from 1.1.53).
 „ Mr. V. N. Gadgil, M.sc. (on deputation from Nagpur University)
Attached workers—Mr. D. K. Chakraborty, M.sc., (R. G. Kar Medical College)

Miss. Madhuri Duttā, M.Sc. (Lady Brabourne College)

Dr. (Mrs) Santi Batra, M.A., PH.D. (Cornell) (Lady Brabourne College)

Dr. C. T. Datta, M.Sc., PH.D. (Lond)

Mr. Atindriya Bose, M.A. (Ramkrishna Mission Vidyamandir, Belur Math)

Mr. Radhabinod Majumdar M.A. (Vidyasagar College)

Mr. Prasanta Dutt M.Sc.

Dr. S. N. Bhaduri, M.Sc., PH.D. (Lond) (Government College, Darjeeling)

Department of Microbiology:

Research Fellow—Dr. P. N. Nandi, M.Sc., PH.D. (Lond)

Sir J. C. Bose Scholar—Mr. G. P. Sen, M.Sc. (from 1.4.52)

„ Mr. Ajit Kumar Banerjee, M.Sc. (from 2.3.53)

Attached worker—Mr. S. K. Mookerjee, M.Sc. (Surendranath College)

Department of Physiology:

G. C. Bhattacharya.

STAFF APPOINTED UNDER GRANT-IN-AID SCHEMES

A. Department of Physics

Board of Research on Atomic Energy

i) Transuranic elements and nuclear fission of heavy elements

Dr. S. D. Chatterjee D.Sc. (*Honorary*)

Dr. M. S. Sinha, D.Sc.

Mr. I. L. Chakraborty, M.Sc.

Mr. A. M. Ghosh, M.Sc.

Mr. N. K. Ganguly, M.Sc.

Mr. N. C. Das, M.Sc. (from 1.3.52).

Mr. N. N. Biswas, M.Sc. (from 4.5.52).

ii) Use of Photographic Plates for the Study of nuclear disintegration

Mr. S. P. Dutta, M.Sc. *Honorary*

ii) Setting up of Medium voltage ray discharge tube

Mr. A. N. Banerjee, M.Sc.

Mr. H. Raha.

B. Department of Chemistry*Indian Central Jute Committee*

Impregnation of bleached jute yarns with suitable synthetic Resins.

Mr. R. P. Chatterjee, M.Sc.

Mr. A. C. Ghosh, M.Sc.

C. Department of Botany*Indian Central Jute Committee*

Production of suitable mutants in Jute by X-ray irradiation

Mr. R. K. Basu, M.Sc.,

Mr. B. C. Mookerjee, M.Sc.

Indian Central Oilseeds Committee

Inducing mutants with economic characters in til, rape & mustard by X' ray

Mr. K. L. Chowdhury, M.Sc.

Mr. Ashoke Das, M.Sc.

Government of West Bengal—Cotton Scheme

Mr. A. K. Adhikari, M.Sc. (also In-Charge of the farm at Falta)

Sir J. C. Bose Research Fellow (Calcutta University)

Miss Mridula Datta, M.A.

Indian Council of Agricultural Research

Scheme for the eradication of weeds in crop fields

Mr. K. George, M.Sc.

Mr. M. G. Srivastava, M.Sc. from 1.1.53.

National Institute of Sciences of India— I.C.I. Fellow

Dr. A. Ganguly, B.Sc., PH. D. (Edin)

Gm